Mix, Gibbs, Harris

Tests of a Bogart Gas Engine

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TESTS OF A BOGART GAS ENGINE

BY

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THESIS

FOR

DEGREE OF BACHELOR OF SCIENCE

IN

MECHANICAL ENGINEERING

COLLEGE OF ENGINEERING

UNIVERSITY OF ILLINOIS

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Martin Ira Mix, Paul Hedges Gibbs, and Roscoe Conkling Harris

ENTITLED Tests of a Bogart Gas Engine

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science in Mechanical Engineering

C. P. Richards
Instructor in Charge

APPROVED: C. P. Richards

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TESTS OF A BOGART GAS ENGINE.

Introduction.

The tests run for this thesis were made in groups in which some one factor was varied, the variable being carried to such extremities as were obtainable with the engine. Inasmuch as the engine tested was only recently installed and the tests here recorded the first to be run, the data obtained will be of some interest. It will be noted that the tests were not conducted according to the standard code. The reason for the divergence lies in the fact that two of the authors of this thesis originally intended to determine "n" under variable conditions, and the data obtained taken for the thesis of M. I. Mix at the same time. Due to the fact that the values of "n" obtained were absurdly low, the work was abandoned and Messrs. Harris and Gibbs colloborated with M. I. Mix in the production of this thesis.

The logarithmic diagrams used to determine "n", as explained later, showed little leakage, but a further investigation with the use of compressed air showed considerable leakage. The engine was set on dead center and compressed air led into the cylinder at the side of the indicator cock. Two globe valves were attached above and below a gage situated immediately above the inlet. By admitting air under pressure and turning off the feed, the fall in pressure due to leakage was read

on the gage. As the time allowed for thesis work did not allow the replacement of the piston rings and the detection of other leakage, the thesis above mentioned was dropped.

CHAPTER I.

Description of Engine and Auxiliaries.

1.- Description of Engine. - The engine tested was a gas engine manufactured by the Bogart Gas Power Engineering Company of Buffalo, New York. The engine is rated at 15 H. P. on matural gas, and runs at 325 r. p. m. The dimensions of the cylinder are ten inches diameter by a nine inch stroke. The piston has three rings and runs in a heavy cast iron cylinder, the piston rod being attached to the crosshead which in turn is connected to the crank pin through the usual connecting rod. The crank pin operates centrally between two heavy fly- wheels. The crank shaft is connected to the lay shaft M. Fig. II. by spiral gears L. Attached to the lay shaft is the timer E, the cam F operating the inlet and exhaust ports and also a small cam for operating a small plunger pump used in feeding the gasoline from the tank D to the vaporizer A, Fig.III. The lay shaft also drives a vertical governor, B Fig.II., of the enclosed fly-ball type, by means of spiral gears. The governor is connected to a butter-fly valve located just beyond the mixing chamber B, Fig. III. The valves C and I Fig. II. are of the vertical poppett type and are seated in a water jacketed cage which is ground jointed to the cylinder. The main ignition plug G. is studded to ground joint at the side of the cylinder. The timer E is adjustable while the engine is operating and

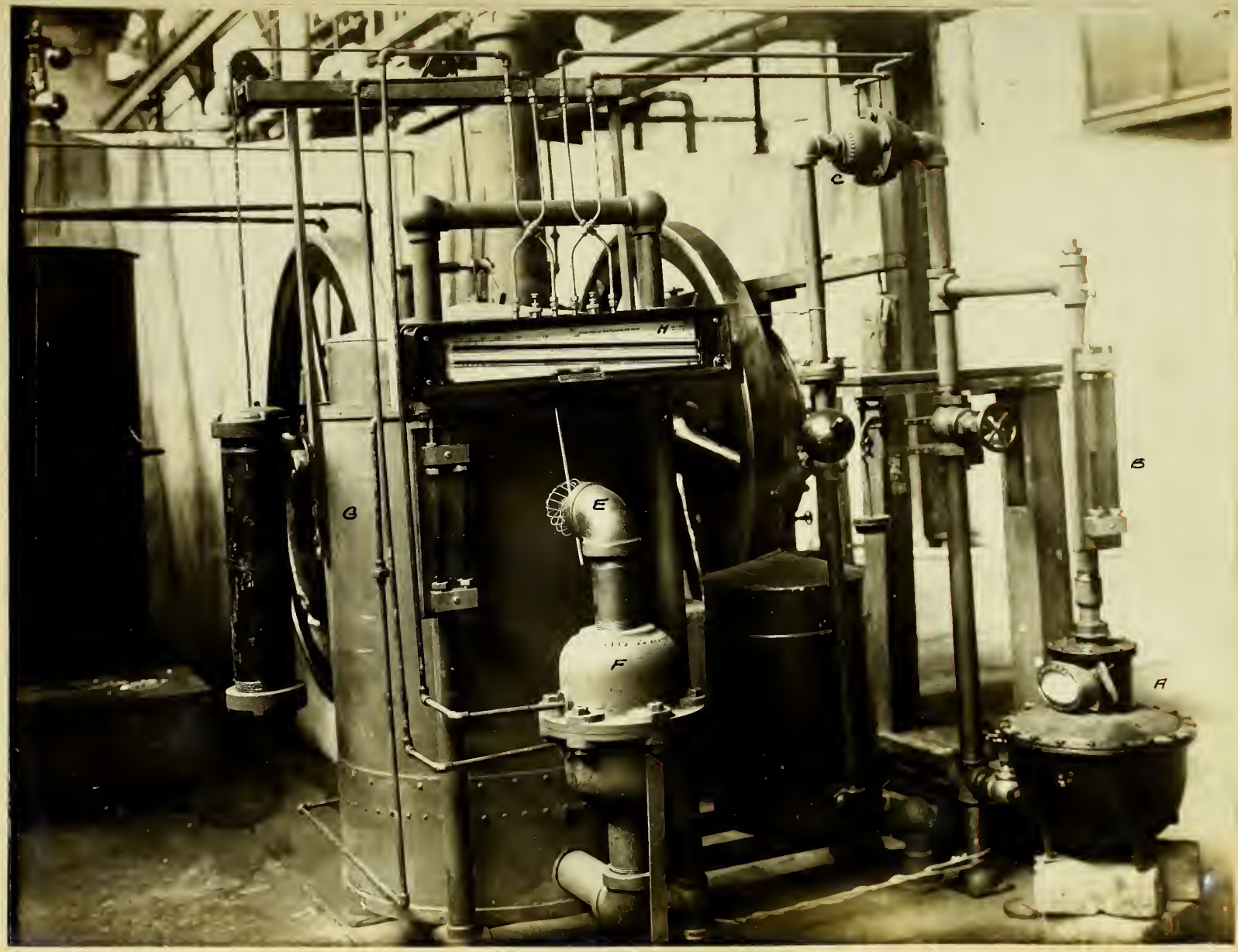


FIG. I

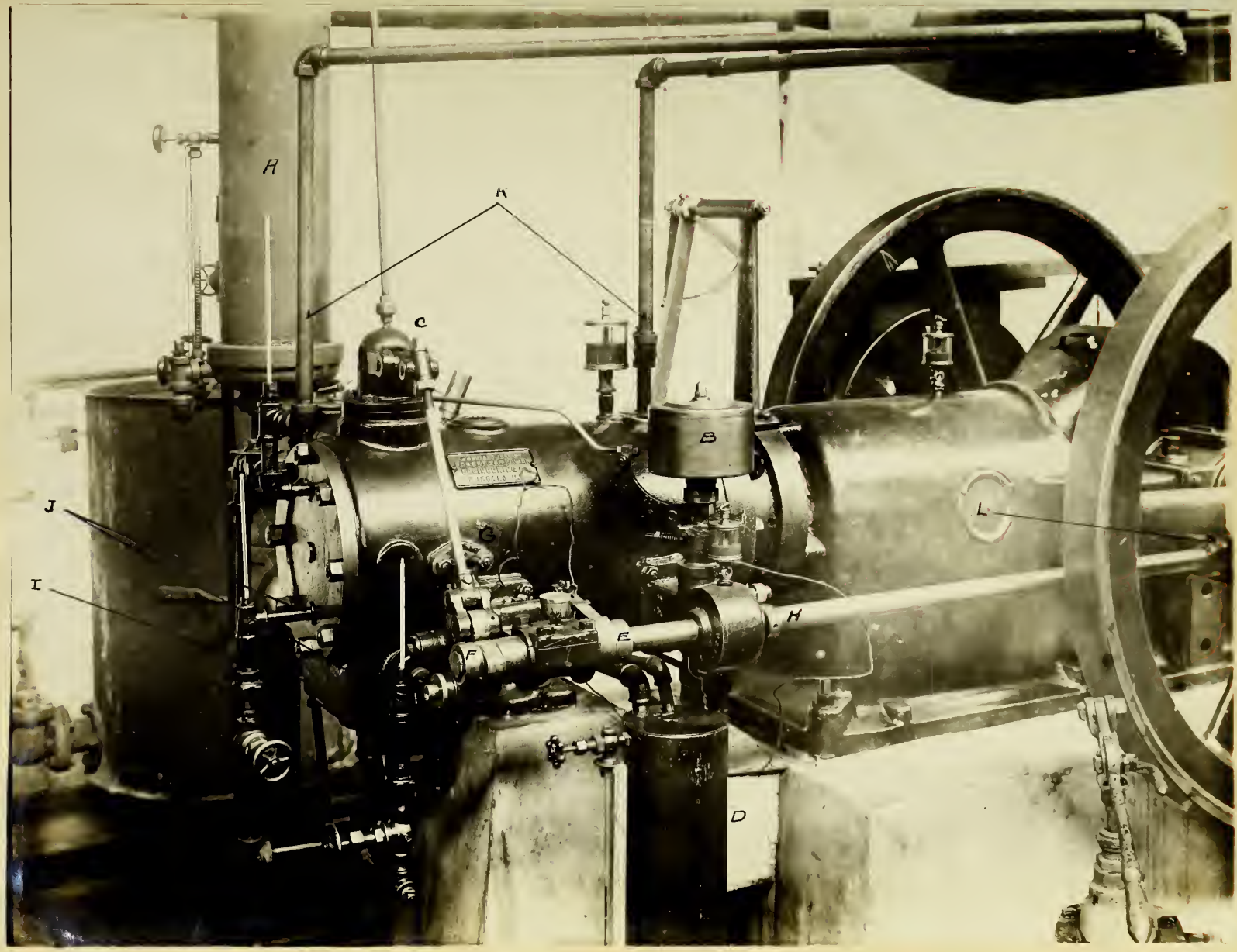


FIG. II

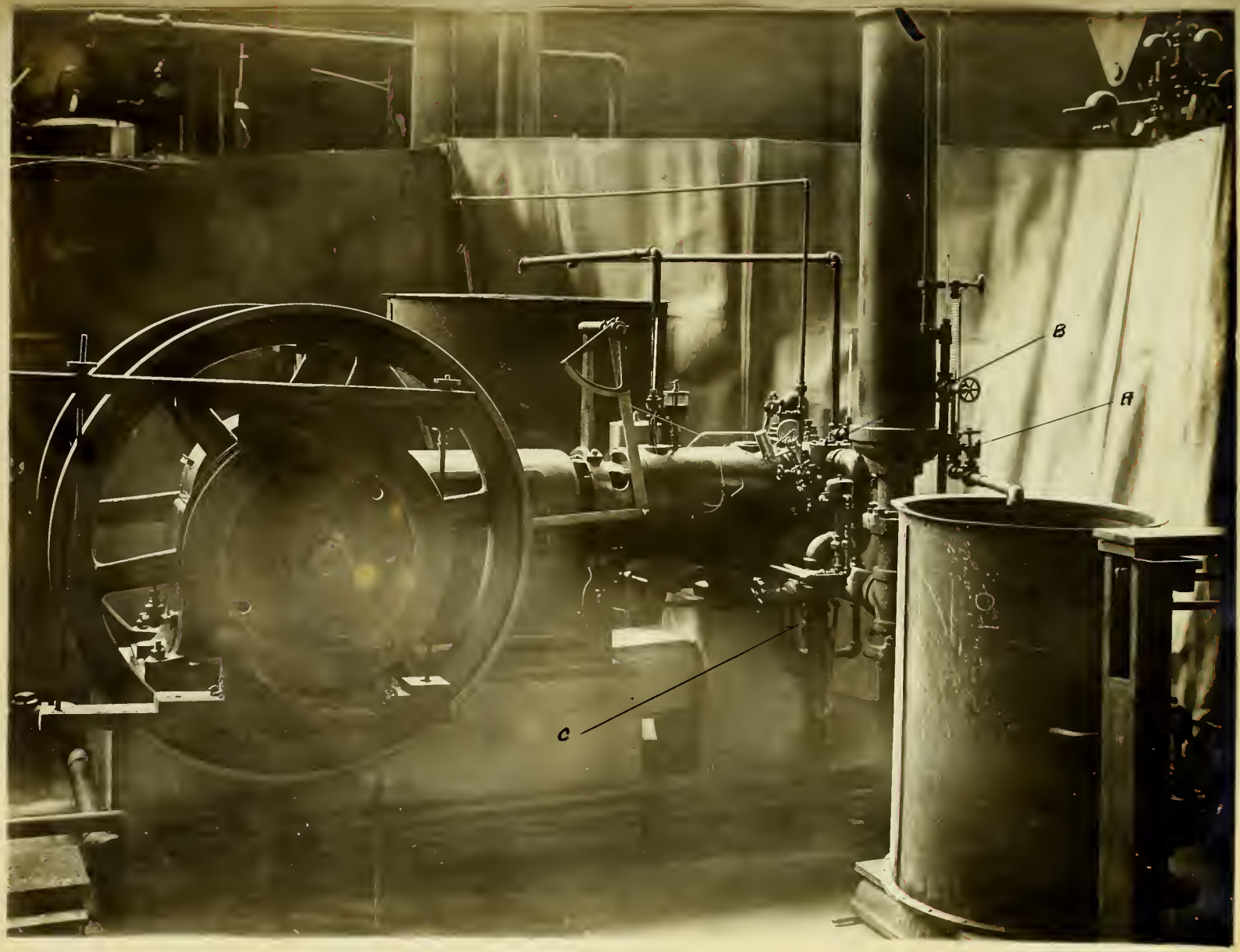


Fig. III

can be adjusted for late ignition in starting and advanced to the most efficient running position and locked. The cylinder and cylinder head are separately jacketed so that it is possible to isolate the heat losses at the two points. A valve is located on the end of the gas lead controlling the amount of gas used. The air used for gas combustion is brought into the mixing chanber by the suction of the gas engine, which lifts an aluminum drop valve admitting the air. This valve is seated when running on gasoline, the air being brought in nearer the vaporizer.

2.- Description of Fuel Appliances. - (a) Gas Economizer. - The gas and air mixtures were determined by a gas economizer manufactured by the Meriam Company of Cleveland, Ohio. The gas is led from a wet meter A, Fig. I., thru a three-quarter inch hole located in a copper diaphragm, small pipes leading from each side to a calibrated liquid manometer which indicates directly the amount of gas per hour used by the engine. The gas is then led to a small balanced holder D, and then to the engine. The air is taken directly from the engine room thru the pipe E and is led thru a copper diaphragm containing eight three-quarter inch holes, the amount of air being used is read from a manometer as before. The air passes to a balanced holder G and then to the engine.

(b) Exhaust Gas Calorimeter. - The amount of heat lost in the exhaust gases was measured by exhausting thru a calorimeter in which a series of baffles allowed water entering at the top to come in contact with the rising gases, thus absorbing the heat from the gases. The water trickles over the baffle plates to the bottom of the calorimeter and is drawn off into a weighing tank. The apparatus is so arranged that the last baffle throws the water to the outside of the calorimeter. The exhaust pipe extends into the calorimeter and allows water to gather around it to a depth of eight to ten inches as shown on a gage glass. In this manner the maximum flow of water thru the apparatus is determined without the danger of overflow into the exhaust pipe.

(c) Gasoline Vaporizer. - The vaporizer A Fig. III., is supplied with fuel by a gasoline pump driven from the lay shaft. The gasoline is kept at a constant level in the vaporizer reservoir by means of an overflow pipe which returns the excess gasoline to the fuel tank. The level of the gasoline is kept at approximately one-half inch below the spray nozzle. The gasoline is drawn into the vaporizer on each suction stroke, due to the slight vacuum created and is absorbed by the air passing over the spray nozzle.

CHAPTER II.

Description of Calibrations and Methods.

3.- Calibration.- (a) Indicator Springs.-- The apparatus used to calibrate the indicator springs consisted of a steam drum connected by a siphon connection to the indicator. The drum is connected at one end to a mercury column and steam pressure is applied by throttling the admission or discharge. The indicator was well oiled and attached. Paper was put on the drum and steam pressure turned on until the instrument became warm. The steam pressure was then turned off, and by pressing the pencil against the paper and revolving the drum by hand, the atmospheric line was obtained. Pressure was applied by increments equal to one-fifth the value of the spring; the motion being constantly upwards, stopping only to draw lines for the determined pressures. Pressures were applied to fifty per cent. over the rated value of the spring. The above operation was repeated, starting with the maximum value and decreasing the pressure by equal increments. The average position or mean line of the ascending and descending increments gave the ordinate corresponding to that pressure. The spring used thru-out the tests was approximately correct until overloads of forty to fifty per cent. were reached, and as this condition was never obtained during the test, the spring was accepted as correct.

(b) Gasoline Tank. - The gasoline tank was weighed dry and when filled with water; the water being poured in until the manissca was just visible at the top of the gage glass. The temperature of the water was taken and the density of gasoline corresponding to that temperature used in finding the weight of gasoline in the tank. The water was warmed to about 75 degrees F. as this is an average temperature in an engine room, thus giving an approximately average calibration. The visible length of the gage glass was then measured and divided by the contents of the tank in pounds, thus determining the length of gage glass per pound of gasoline.

4.- Method of Setting the Engine on Dead Center.- The engine was turned over until it was nearly on dead center. A coincident mark was then made on the cross-head and on the bed of the engine. An available and permanent point was marked on the engine and one point of a tram inserted in this mark. A mark with the other point of the tram was made on the fly-wheel. The engine was turned past dead center until the marks on the crosshead and the bed again coincided. A mark was made on the fly-wheel with the tram as before. The bisection of these points gave a permanent point of reference for setting the engine on dead center.

5. - Method of Determining the Clearance. - The engine was set on dead center and a determinable weight of water poured in until it filled the clearance space. The temperature of the water was taken thus determining by the aid of tables the weight of water per cubic foot. Knowing the dimensions of the engine, the clearance in per cent. of stroke was easily calculated.

6. - Method of Varying the Clearance. - The clearance was varied by screwing the piston rod into the crosshead and locking the setting by means of a heavy locknut revolving on the piston shaft.

7. - Method of Determining the Point of Ignition.- The engine was turned over until the ignition was made, a point being marked at the instant on the fly-wheel with a tram. The distance between the mark obtained and the dead center point gave, when divided by the circumference of the wheel, the percentage of the angular displacement of the wheel per revolution at which ignition occurred.

8. - Method of Determining the Brake Constants.- The weight of the brake arm was determined by revolving the flywheel in one direction and then reversing, taking the weight of the arm in each instance by means of a small scale. In the first case, the effects of friction and the weight of the arm

are measured, while in the second t e weight minus the friction is measured; thus an average value of the two readings gives the true weight of the brake arm.

9. - Method of Determining the Heating Value of the Fuel. - The heating value of the fuel was obtained by the use of a Junker calorimeter. The gas was metered, sent thru a pressure regulator and burned. The combustion products pass to the top of the combustion chanber and from there thru double rows of vertical tubes to the uptake chamber and exit flue at the base of the chamber. While passing out the gases are thoroughly cooled and condensed by the cooling water which surrounds the tubes and the combustion chamber.

The cooling water enters a constant level chamber and flows at constant head to the apparatus thru a regulating cock.

The temperature of the cooling water is measured by theromometers provided at the inlet and discharge of the apparatus. The water is discharged thru a free level chamber. The condensation resulting from the combustion of hydrogen collects in the bottom of the uptake chamber and is drained into a measuring glass.

The heating value is obtained from the following formula where-

V = Volume of gas consumed reduced to 62 degrees F. and 14.7 pounds pressure.

W = Weight of cooling water in kilograms

T_2 = Mean discharge temperature - centegrade

T_1 = Mean inlet temperature - centegrade

H = Heating value per cubic foot.

$$H = 3.968 \frac{W (T_2 - T_1)}{V}$$

10.- Methods of Conducting the Tests. - In performing these tests, the load on the engine was kept constant, with the exception of Tests 17, 18, 19, in which the load was slightly increased to avoid excessive piston speed. The work was proportioned so that the most important readings were taken simultaneously. A complete set of readings was taken every five minutes, a test continuing for one-half hour. The arrangement of the work was as follows: - The indicator cards, engine speed and brake readings were taken by one member of the party; inlet and outlet jacket water temperatures and their weights by second member, and the temperature and weight of calormeter water, the gas or gasoline, and air readings and their temperatures and pressure by a third member of the party.

In all twenty-seven tests were run on city gas and gasoline, these tests being divided into eight series. In each series some condition was varied between extreme limits, all the other factors being kept constant. Tests 1 - 6 inclusive were con-

ducted with variable jacket water temperatures. Tests 7 - 10 inclusive, were conducted with variable gas and air ratios; 11 - 16 inclusive, with variable ignition, and 17 - 19 inclusive, with variable air and gas ratios. The clearance used thruout these series was 19.04% of the stroke. Tests 20 - 21 inclusive, were run with varying air and gas ratios with the clearance volume increased to 25%. Tests 22 - 24 inclusive, included variable air and gasoline ratios with the same clearance volume. The last three tests were conducted with a clearance volume of 27.76% and with variable air and gas and air and gasoline ration.

CHAPTER III.

The Determination of the Variable "n".

11.- The variable "n" is probably familiar to all students of thermodynamics as occurring in the gas equation $PV^n = C$. Very little work has been done on the determination of the values, as applied to gas engines under variable conditions of operation, and it was with this point in view that Messrs. Gibbs and Harris were assigned this subject for a thesis, Although the results obtained had to be rejected because of certain mechanical difficulties, a brief description of the method may be of interest.

As has been explained before, half-hour tests were run, the cards and readings being taken at equal intervals of time. These diagrams are then integrated, and their M. E. P. determined. A card is then selected which is typical of the test, both in M. E. P. and R. P. M., and is plotted on logarithmic paper.

The method of transfer to logarithmic paper is as follows. From 20 to 30 points are selected on the P. V. diagram, and since these points correspond to certain absolute pressures and volumes, their coordinates are plotted on the logarithmic paper. These points are then connected by a smooth curve, from which a complete and accurate analysis of the engine performance can be obtained. The expansion and compression curves gradually merge into straight lines from which the value of "n" may be determined by the slope of the line. A justification for this

method may be found in the following mathematical deduction:

Given: - $PV^n = C$

Taking logarithms of both sides -

$$\text{Log } P = -n \text{ Log } V + \text{Log } C$$

Since the equation of a straight line is

$$Y = mx + b$$

$$Y = \text{Log } P$$

$$x = \text{Log } V$$

$$b = \text{Log } C$$

$$m = -n$$

Thus m the slope of the straight line corresponds to -n, the slope of the expansion and compression curves, when plotted on logarithmic paper.

In addition to giving accurate values of "n", the logarithmic diagram is also useful in determining leakage. This is easily seen on the plotted diagram by a bulging out of the expansion and compression lines at its ends, the top ones indicating leakage out of the cylinder, and the lower ones leakage into the cylinder.

Since it was observed that the compression pressure was far too low for the clearance volume, it was decided to test the engine for leakage with compressed air, and upon so doing our fears in this regard were verified. In view of the fact that all of the cards plotted on logarithmic paper gave very straight compression lines, with no apparent leakage at the top or bottom,

the results are rather confounding.

No attempt has therefore been made in this thesis, to connect the values of "n" with any of the various gas engine variables, because of the absurdly low values obtained as a result of this difficulty.

CHAPTER IV.

Discussion, Calculations and Conclusions.

12. - Discussion.- The results obtained and their relation to the operation of the engine are best seen when plotted on coordinate paper. Thus constant reference to the curves drawn for the various tests will be made in this discussion.

The load on the engine was kept constant thruout the various tests, thus the mechanical efficiencies varied only within a small range, and no attempt has been made to establish a connection between the maximum mechanical efficiencies obtained and the variables of the various tests.

Curve No. 1. shows the relation between the temperature of the jacket water and the gas consumed per I. H. P. hour and B. H. P hour. The curve shows that the engine was operating most economically at 125 degrees and 105 degrees F. respectively.

Curve No. 2 shows a relation between the jacket water temperatures and the thermal efficiencies per I. H. P. and B. H P. hour. The curve shows that the maximum efficiencies obtained were with jacket water temperatures of 123 degrees F. and 105 degrees F. respectively.

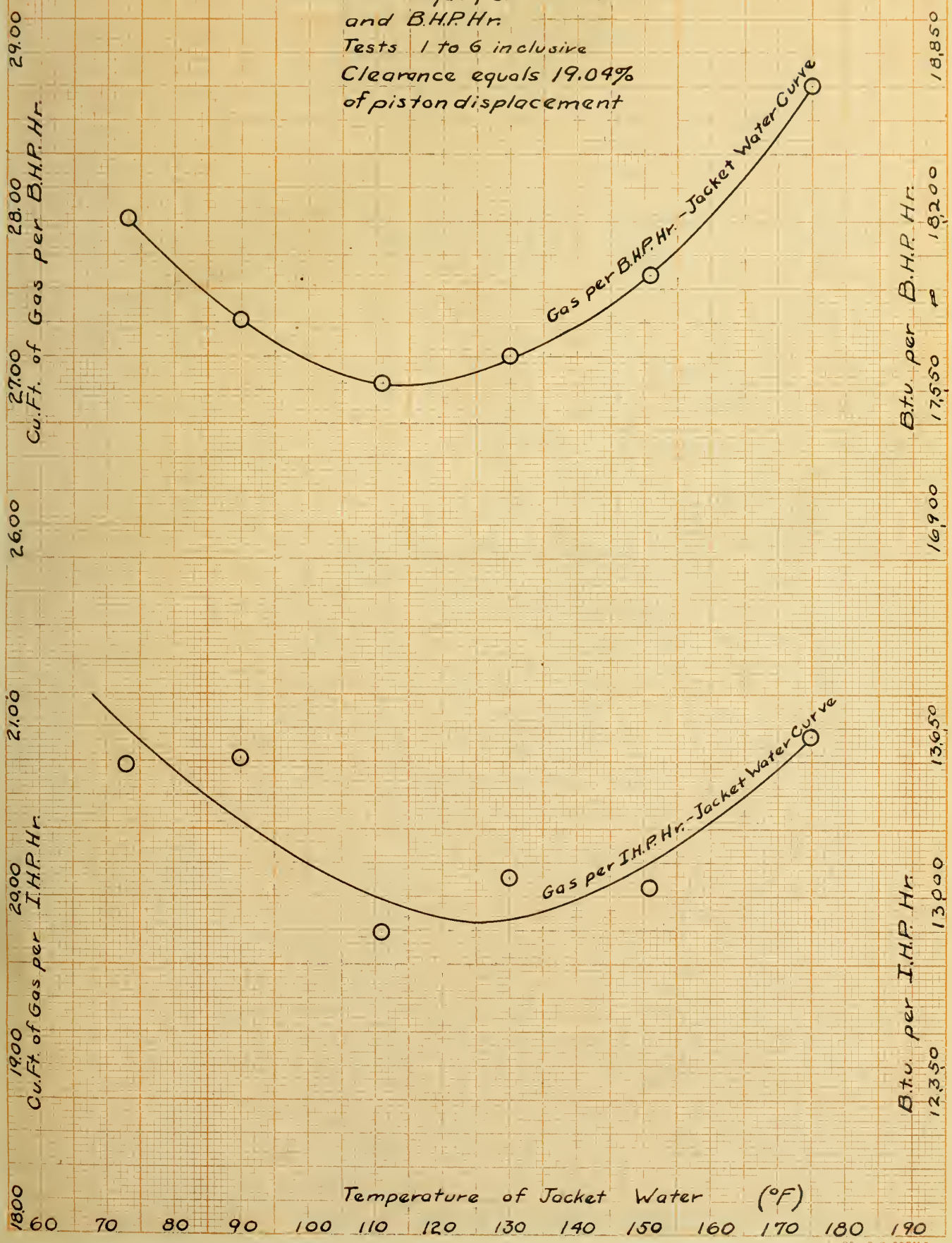
Curve No. 3 shows a relation between the air - gas ratios and the cubic feet of gas per I. H. P. hour and B. H P. hour.

BOGART GAS ENGINE

Relation between Jacket-Water Temperature and Cu.Ft. of gas per I.H.P. Hr. and B.H.P. Hr.

Tests 1 to 6 inclusive

Clearance equals 19.04% of piston displacement



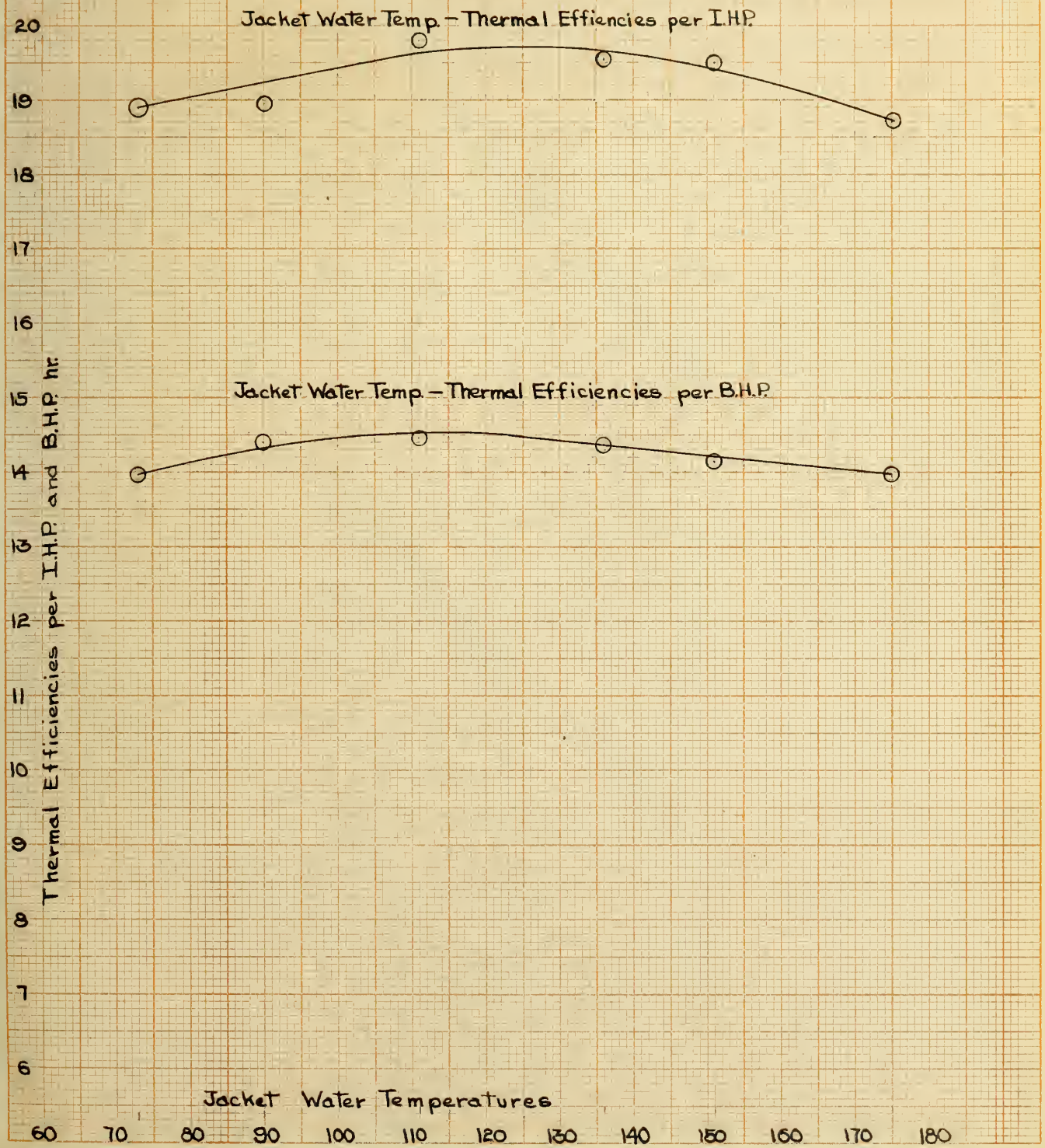
OF . S. S. FORM 3

BOGART GAS ENGINE

Relation between jacket water temperatures and thermal efficiencies per I.H.P and B.H.P.

Tests 1-6 inclusive

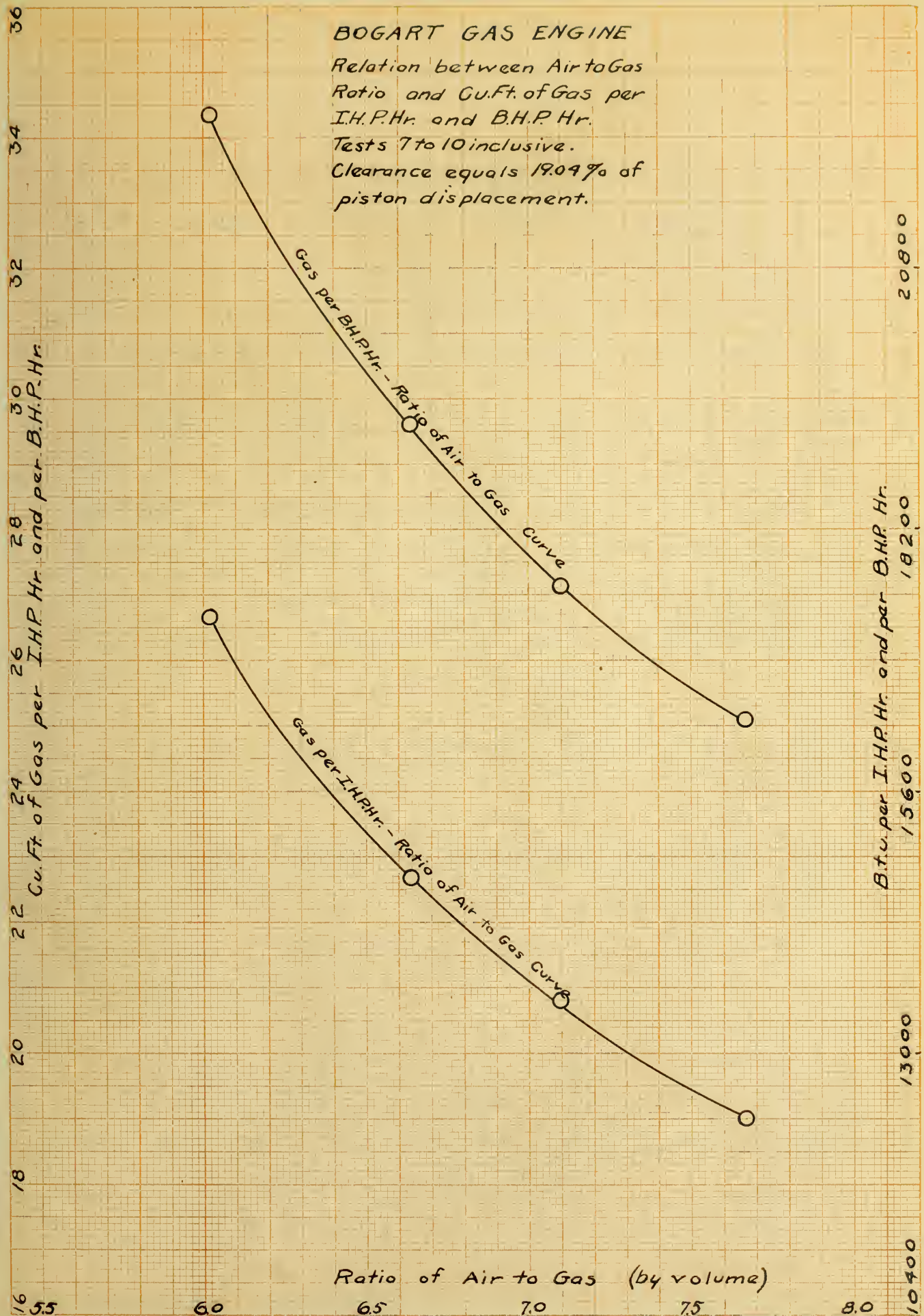
Clearance Volume 19.04% Piston Displacement.



U. OF I. S. S. FORM 3

BOGART GAS ENGINE

Relation between Air to Gas Ratio and Cu.Ft. of Gas per I.H.P.Hr. and B.H.P. Hr.
Tests 7 to 10 inclusive.
Clearance equals 19.09% of piston displacement.



Curve No. 4 shows a relation between the air - gas ratios and the thermal efficiencies. This curve shows that the thermal efficiencies increase as the ratio of air to gas increased. The maximum efficiency obtained in this test was with a ratio of 7.6 : 1, which was the maximum ratio obtainable.

Curve No. 5 shows that the per cent. of heat transformed into work the heat in the jacket water, and the heat in the calorimeter water increasedwith the ratio of air to gas. The maximum efficiency obtained was with a ratio of 7.6 : 1, which was the maximum obtainable ratio. The per cent. of heat lost by radiation decreased with the increase of the air - gas ratio and reached a minimum at this ratio .

Curve No. 6 shows the relation between the air - gas ratio and the point of ignition.

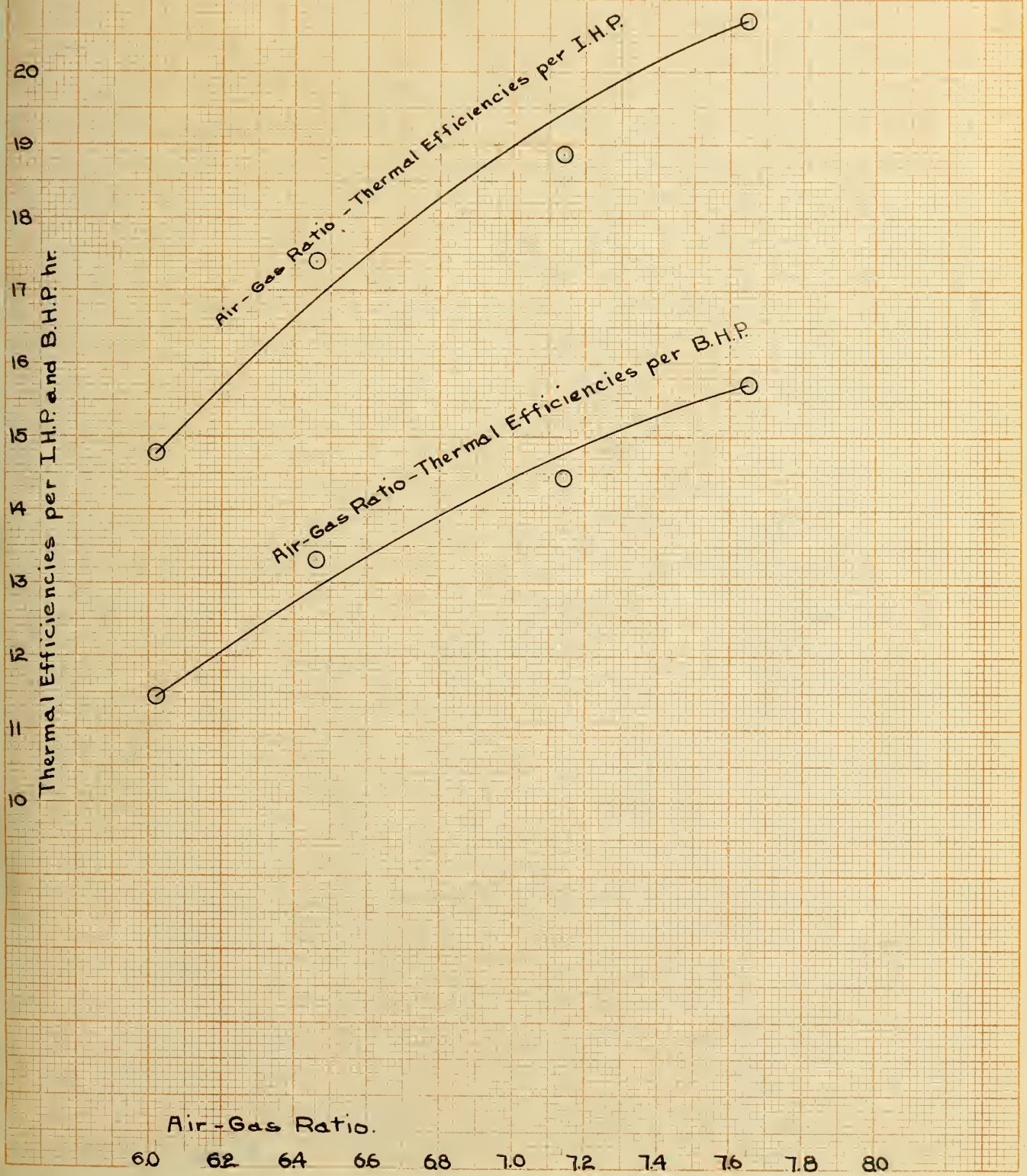
Curve No. 7 shows that the maximum thermal efficiencies per I. H. P. and B. H. P. hour were obtained with a crank angle at the point of ignition at 32 degrees before the end of the compression stroke.

Curve No. 8 shows the relation of the proportions of air to gasoline by weight to the pounds of gasoline per I. H. P. and B. H. P. hour. The most efficient ratio was 20.4 : 1, which was the maximum ratio obtainable.

BoGART GAS ENGINE

Relation between Air-Gas Ratio and Thermal Efficiencies per I.H.P. and B.H.P. hr.

Tests 7-10 inclusive



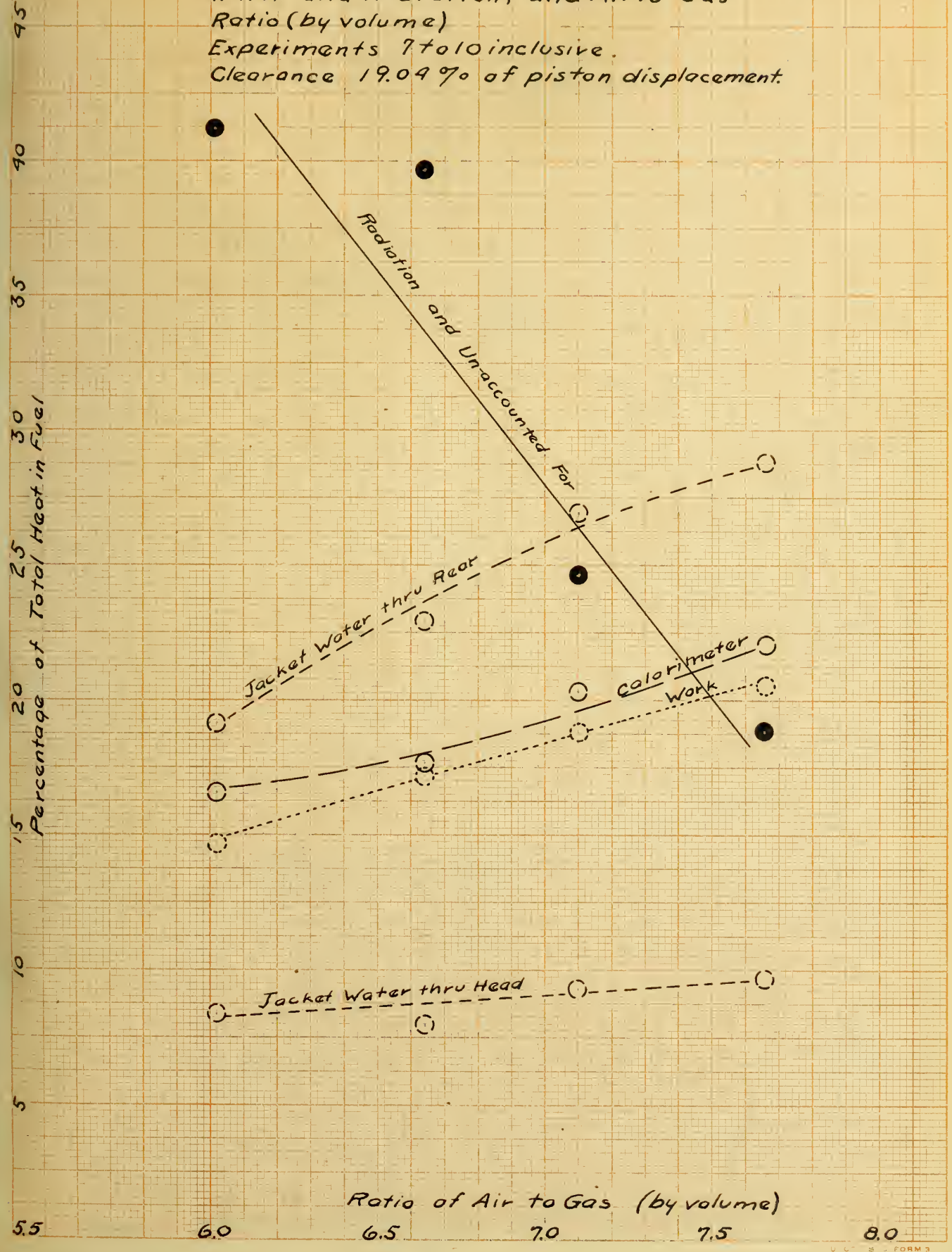
U. OF I. S. S. FORM 3

BOGART GAS ENGINE

Relation between Percentage of Heat taken up by: Work, Exhoust Gases, Jacket Water and Radiation, and Air to Gas Ratio (by volume)

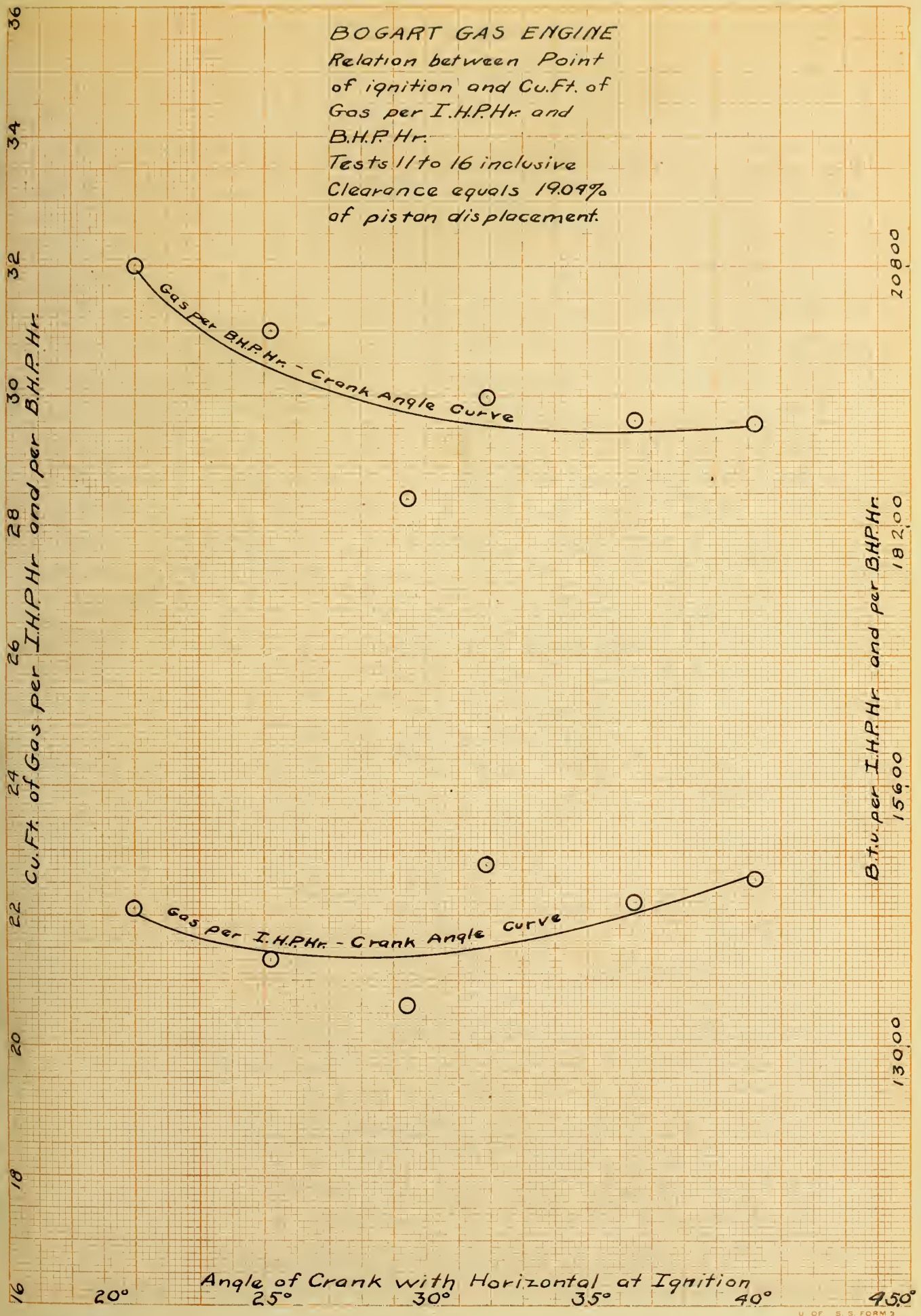
Experiments 7 to 10 inclusive.

Clearance 19.04 % of piston displacement.



BOGART GAS ENGINE

Relation between Point of ignition and Cu.Ft. of Gas per I.H.P.Hr. and B.H.P.Hr.
Tests 11 to 16 inclusive
Clearance equals 19.09% of piston displacement.

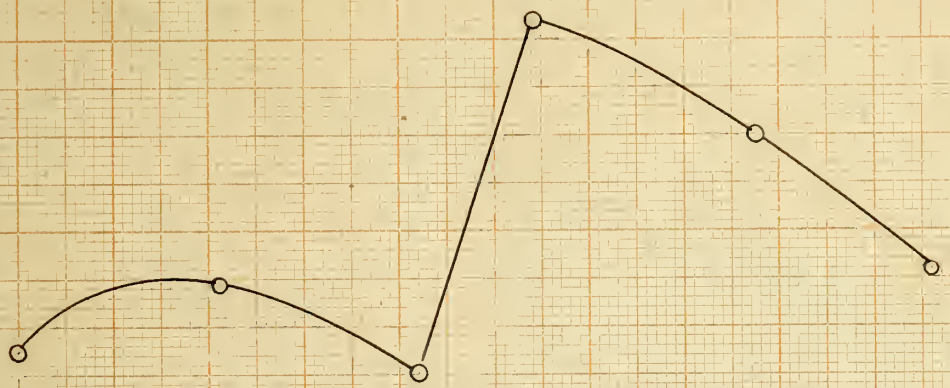


U OF S. S. FORM 3

BOGART GAS ENGINE

Relation between Crank-pin Angle at point of ignition and Thermal Efficiencies per I.h.p and B.h.p. hr.

Tests 11 to 16
Clearance equals 19.04 o/o of piston displacement

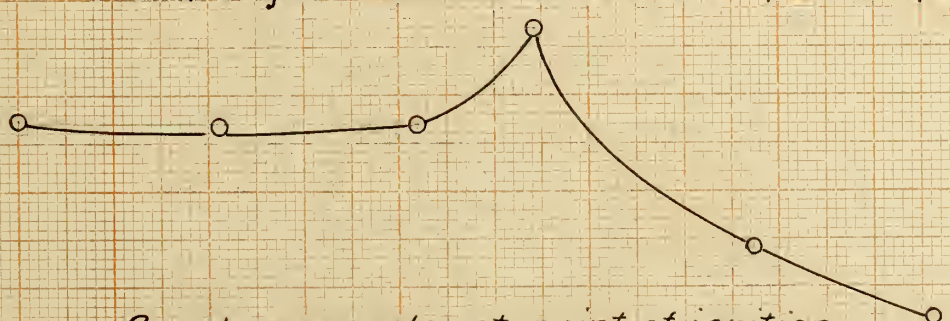


Crank angle – Thermal Efficiencies per I.h.p. hr.

Thermal Efficiencies per I.h.p. and B.h.p. hr.

19
18
17
16
15
14
13

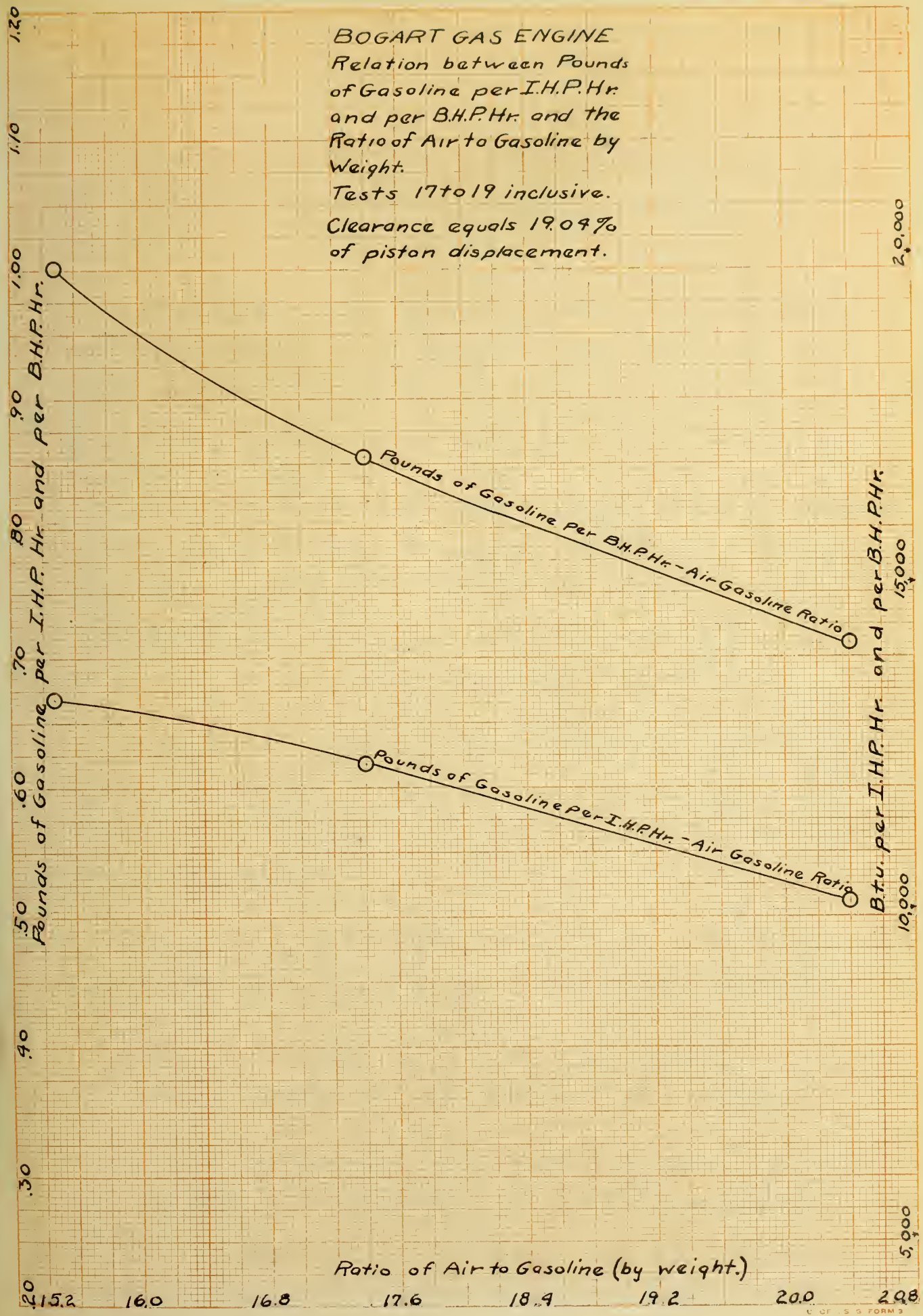
Crank angle – Thermal Efficiencies per B.h.p. hr.



Crank-pin angle at point of ignition

20° 25° 30° 35° 40°

U. OF I. S. S. FORM 3


BOGART GAS ENGINE
Relation between Pounds of Gasoline per I.H.P.Hr. and per B.H.P.Hr. and the Ratio of Air to Gasoline by Weight.
Tests 17 to 19 inclusive.
Clearance equals 19.04% of piston displacement.
Pounds of Gasoline per B.H.P.Hr. - Air Gasoline Ratio
Pounds of Gasoline per I.H.P.Hr. - Air Gasoline Ratio
Pounds of Gasoline per I.H.P. Hr. and per B.H.P. Hr.
B.t.u. per I.H.P. Hr. and per B.H.P.Hr.
Ratio of Air to Gasoline (by weight.)
1.20
1.10
1.00
.90
.80
.70
.60
.50
.40
.30
20,000
15,000
10,000
5,000
15.2
16.0
16.8
17.6
18.4
19.2
20.0
20.8

Curve No. 9. shows that the thermal efficiencies increase and reach a maximum as the ratio of air to gasoline by weight increase.

Curve No. 10 shows that the per cent of heat converted into work, the heat in the calorimeter and jacket waters increase as the air - gasoline ratio increased. The heat lost by radiation decreases as the air - gasoline ratio is increased.

Curve. No. 11 - - The clearance was increased in this series of tests to 25% of the piston displacement. The curve shows that the cubic feet of gas per I. H. P. hour increases slightly with the ratio of air to gas, while the cubic feet of gas per B. H. P. hour remains practically constant.

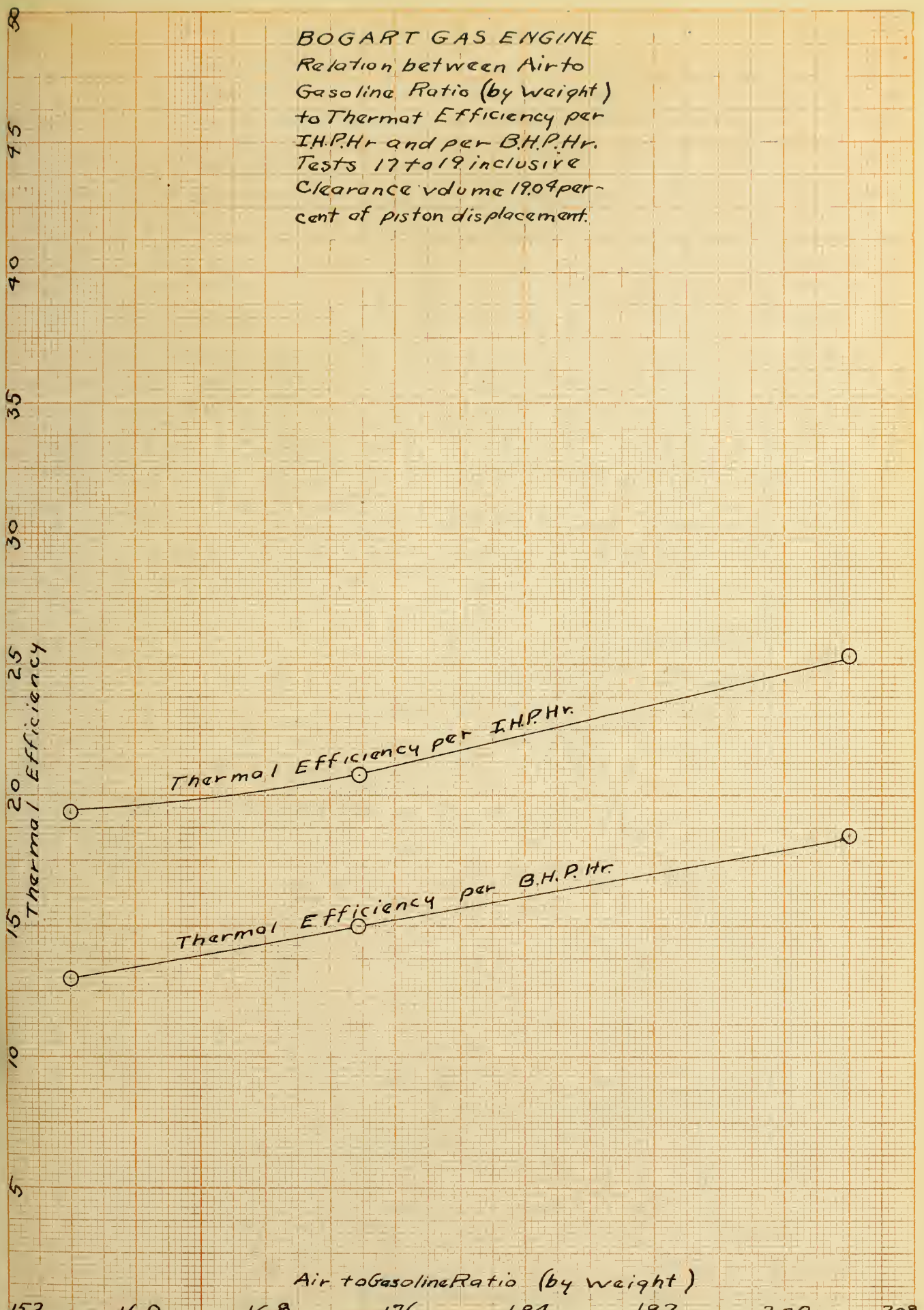
Curve No. 12 shows that the thermal efficiencies per I. H. P. hour decrease as the ratio of air to gas increases. The efficiencies per B. H. P. hour remains constant as the air to gas ratio increases.

Curve No. 13 shows that the gasoline per I. H. P. hour and B. H. P hour decrease as the air - gasoline ratio increases.

Curve No. 14 shows that the thermal efficiencies increase and reach a maximum as the air - gasoline ratio increases.

Curve No. 15 shows that the per cent. of heat converted into work, the heat in the calorimeter and jacket waters decrease with the increase ratio of air to gasoline. The heat lost by

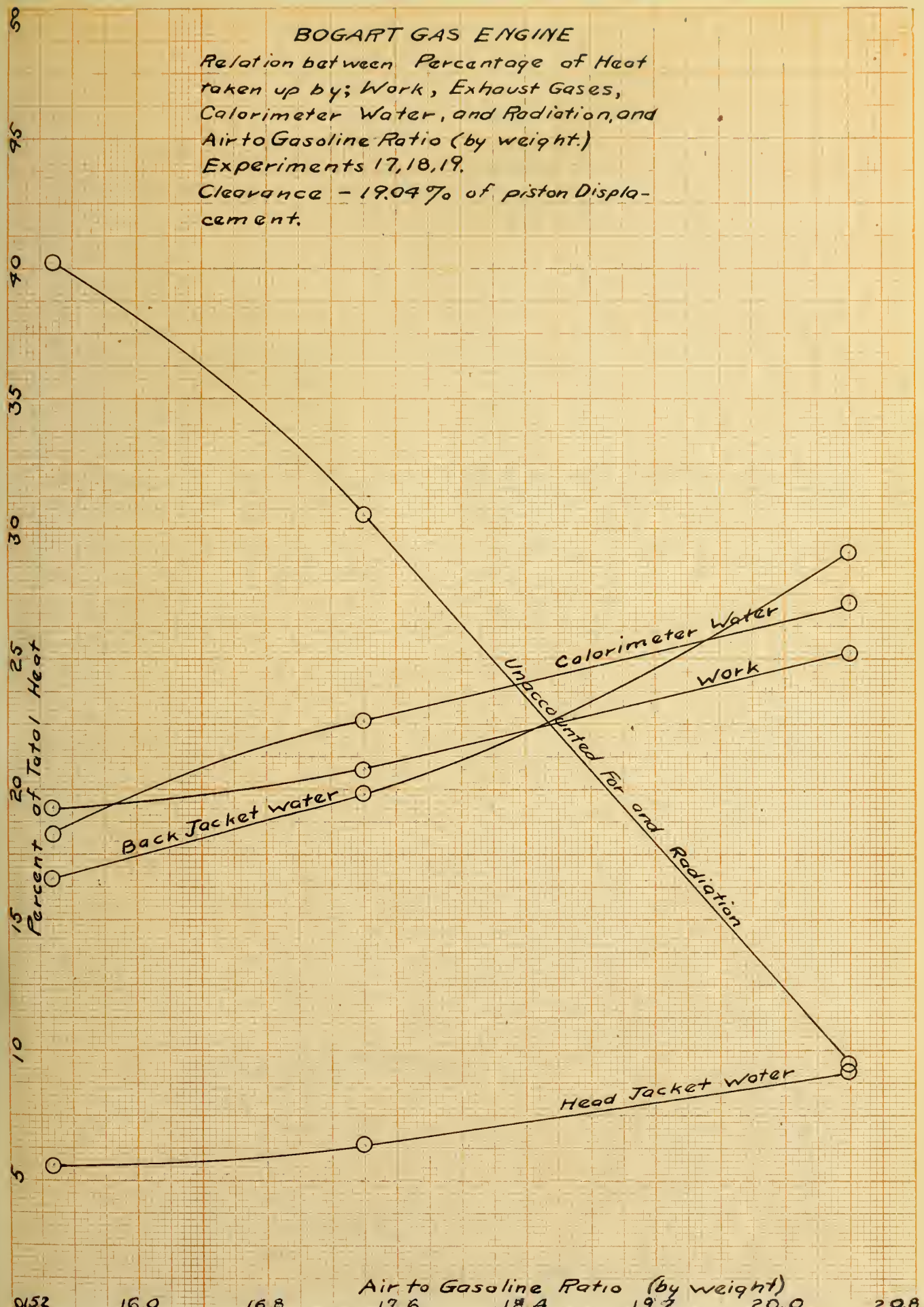
BOGART GAS ENGINE
Relation between Air to Gasoline Ratio (by weight) to Thermal Efficiency per I.H.P.Hr. and per B.H.P.Hr.
Tests 17 to 19 inclusive
Clearance volume 19.09 per-cent of piston displacement.

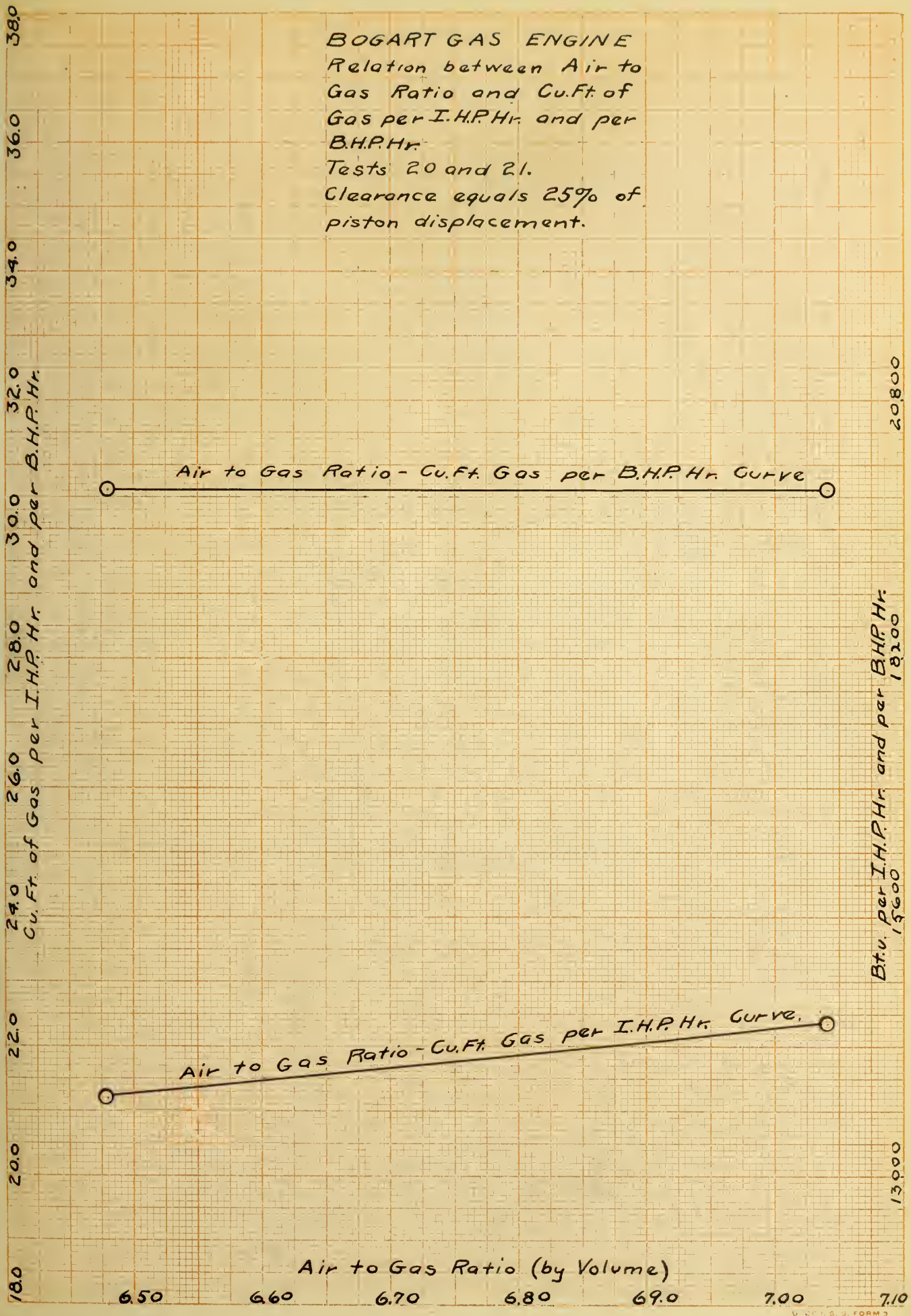


U. OF I. S. S. FORM 3

BOGART GAS ENGINE

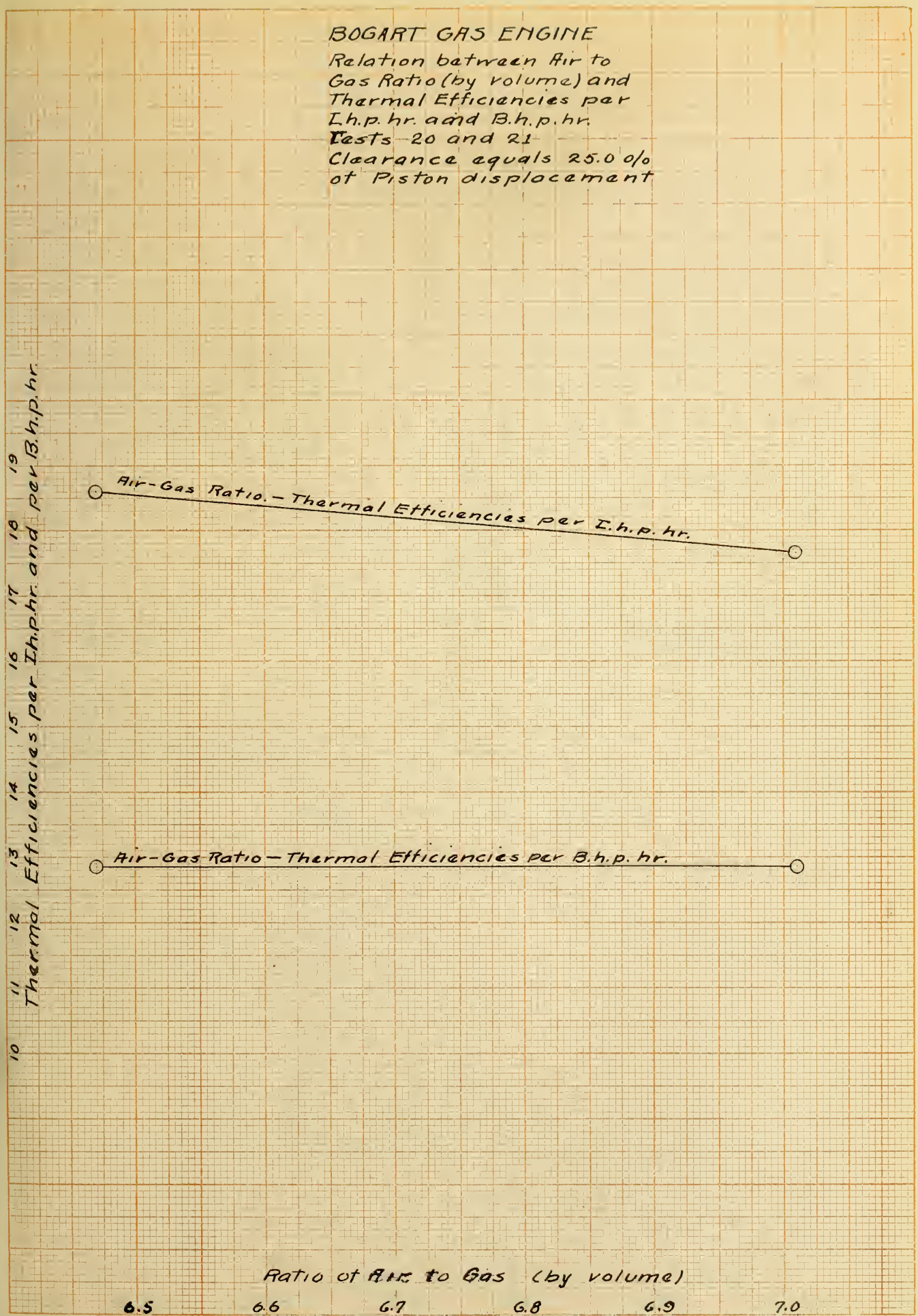
Relation between Percentage of Heat taken up by; Work, Exhaust Gases, Calorimeter Water, and Radiation, and Air to Gasoline Ratio (by weight.)
Experiments 17, 18, 19.
Clearance - 19.04% of piston Displacement.




BOGART GAS ENGINE
Relation between Air to Gas Ratio and Cu.Ft. of Gas per I.H.P.Hr. and per B.H.P.Hr.
Tests 20 and 21.
Clearance equals 25% of piston displacement.
Air to Gas Ratio - Cu.Ft. Gas per B.H.P.Hr. Curve
Air to Gas Ratio - Cu.Ft. Gas per I.H.P.Hr. Curve.
Cu.Ft. of Gas per I.H.P.Hr. and per B.H.P.Hr.
B.t.u. per I.H.P.Hr. and per B.H.P.Hr.
38.0
36.0
34.0
32.0
30.0
28.0
26.0
24.0
22.0
20.0
18.0
20,800
18,200
15,600
13,000
Air to Gas Ratio (by Volume)
6.50
6.60
6.70
6.80
6.90
7.00
7.10

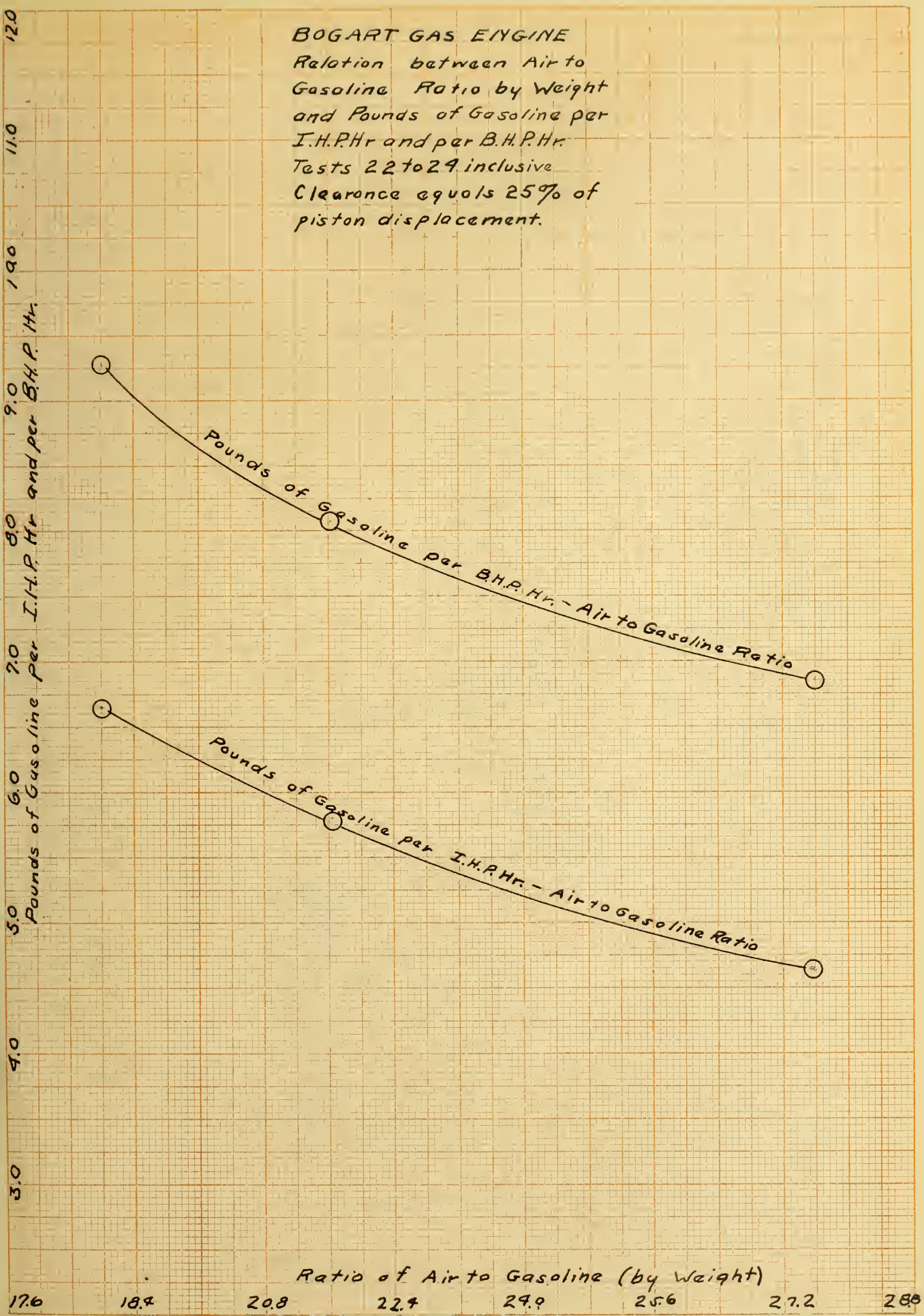
BOGART GAS ENGINE

Relation between Air to Gas Ratio (by volume) and Thermal Efficiencies per I.h.p. hr. and B.h.p. hr.
Tests 20 and 21
Clearance equals 25.0 o/o of Piston displacement



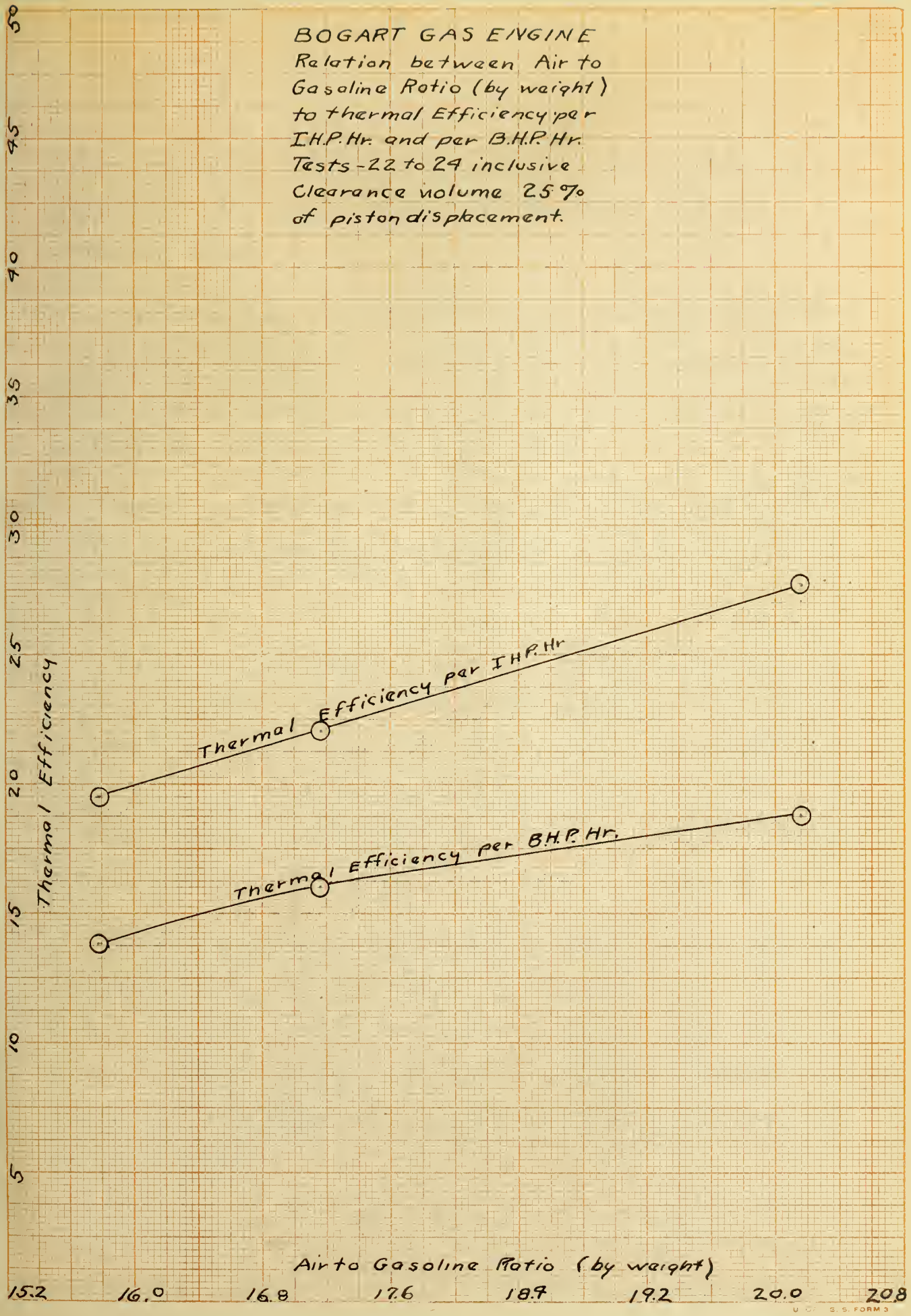
U. OF I. S. S. FORM 3

BOGART GAS ENGINE
Relation between Air to Gasoline Ratio by Weight and Pounds of Gasoline per I.H.P.Hr and per B.H.P.Hr.
Tests 22 to 29 inclusive
Clearance equals 25% of piston displacement.



U. OF I. S. S. FORM 3

BOGART GAS ENGINE
Relation between Air to Gasoline Ratio (by weight) to thermal Efficiency per I.H.P. Hr. and per B.H.P. Hr.
Tests - 22 to 24 inclusive
Clearance volume 25% of piston displacement.



U. S. S. FORM 3

radiation falls off rapidly as the ratio of air to gasoline increases. The heat is nearly all accounted for at the weakest mixture.

Curve No. 16. The clearance was increased to 27.76% of the piston displacement. The curve shows that the cubic feet of gas used per I. H. P. hour and B. H. P. hour decrease slightly as the air - gas ratio increases.

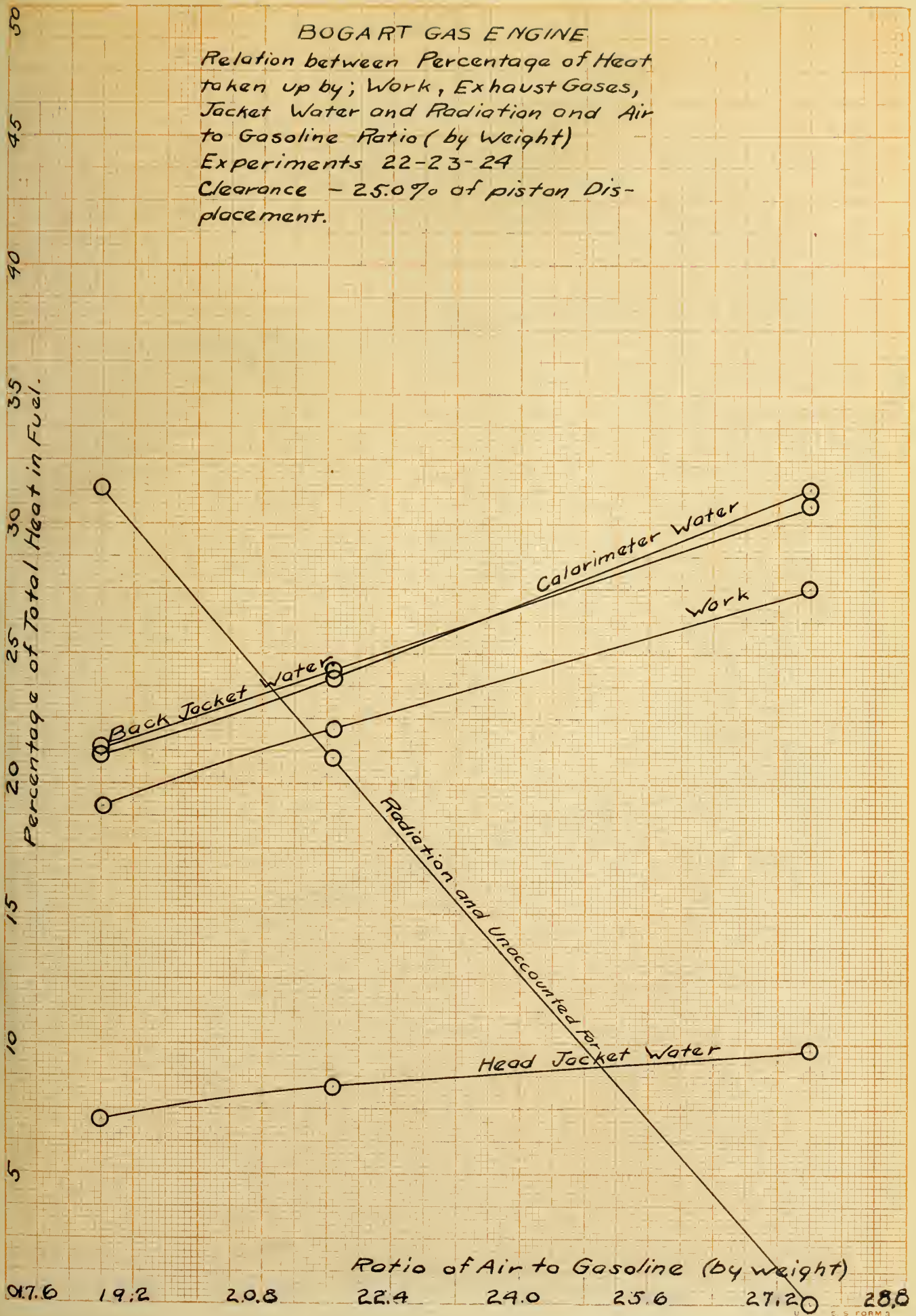
Curve No. 17 shows that the thermal efficiencies per I. H. P. and B. H. P hour decrease slightly as the air - gas ratio increases.

Curve No. 18 shows the relation between the per cent. of clearance volume and the thermal efficiencies per I. H. P. hour with the engine operating on city gas. The thermal efficiencies decrease as the clearance volume increases. The maximum thermal efficiencies obtained in the various tests were used in plotting the curve.

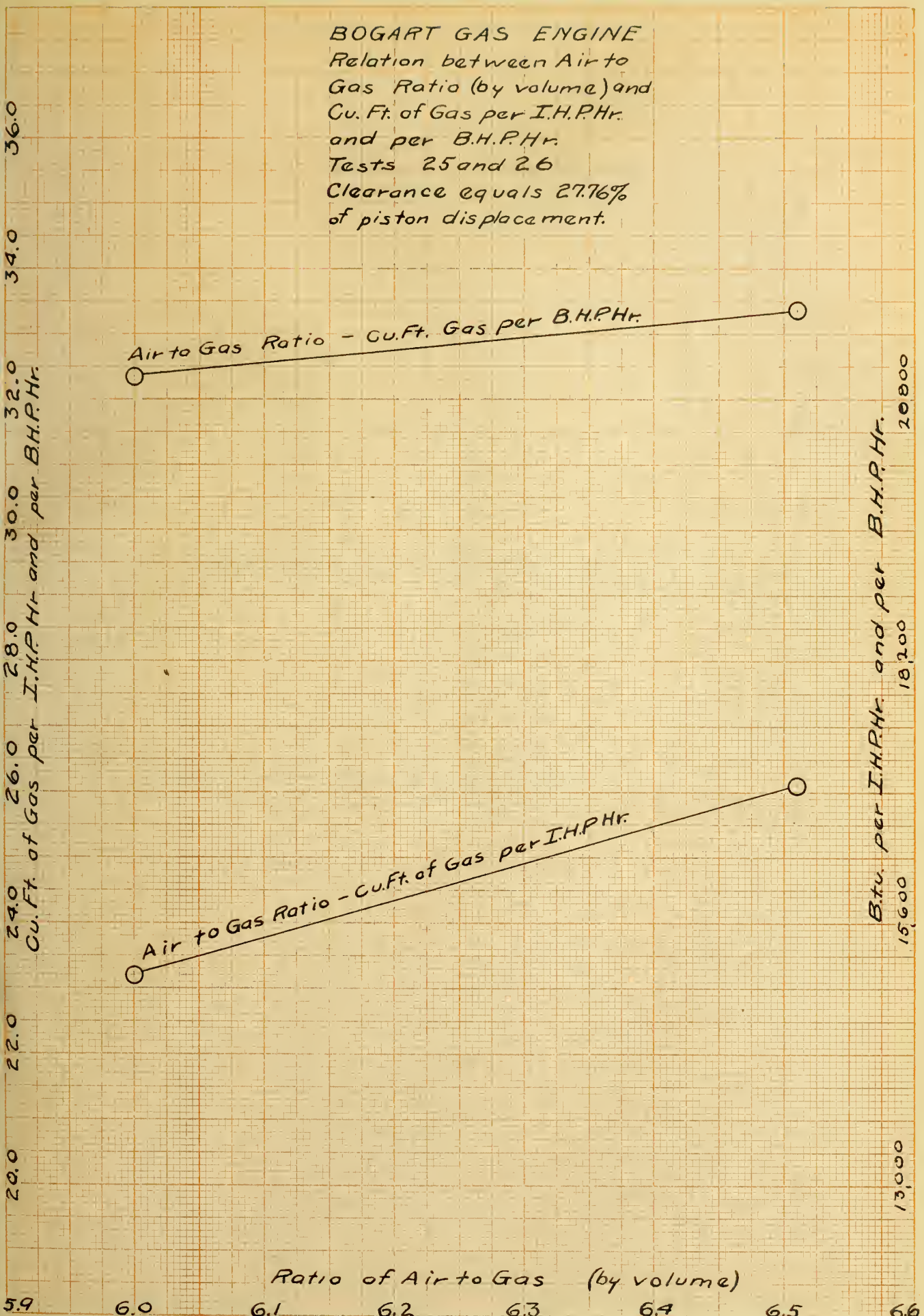
Curve No. 19 shows the relation between the per cent of clearance volume and the thermal efficiencies per I. H. P. hour. The efficiencies increase up to 25 per cent clearance volume and fall off rapidly as the per cent. of clearance increases. The engine was operating on gasoline thruout this series of tests.

BOGART GAS ENGINE

Relation between Percentage of Heat taken up by; Work, Exhaust Gases, Jacket Water and Radiation and Air to Gasoline Ratio (by Weight)
Experiments 22-23-24
Clearance – 25.0% of piston Displacement.



BOGART GAS ENGINE
Relation between Air to Gas Ratio (by volume) and Cu. Ft. of Gas per I.H.P.Hr. and per B.H.P.Hr.
Tests 25 and 26
Clearance equals 27.76% of piston displacement.

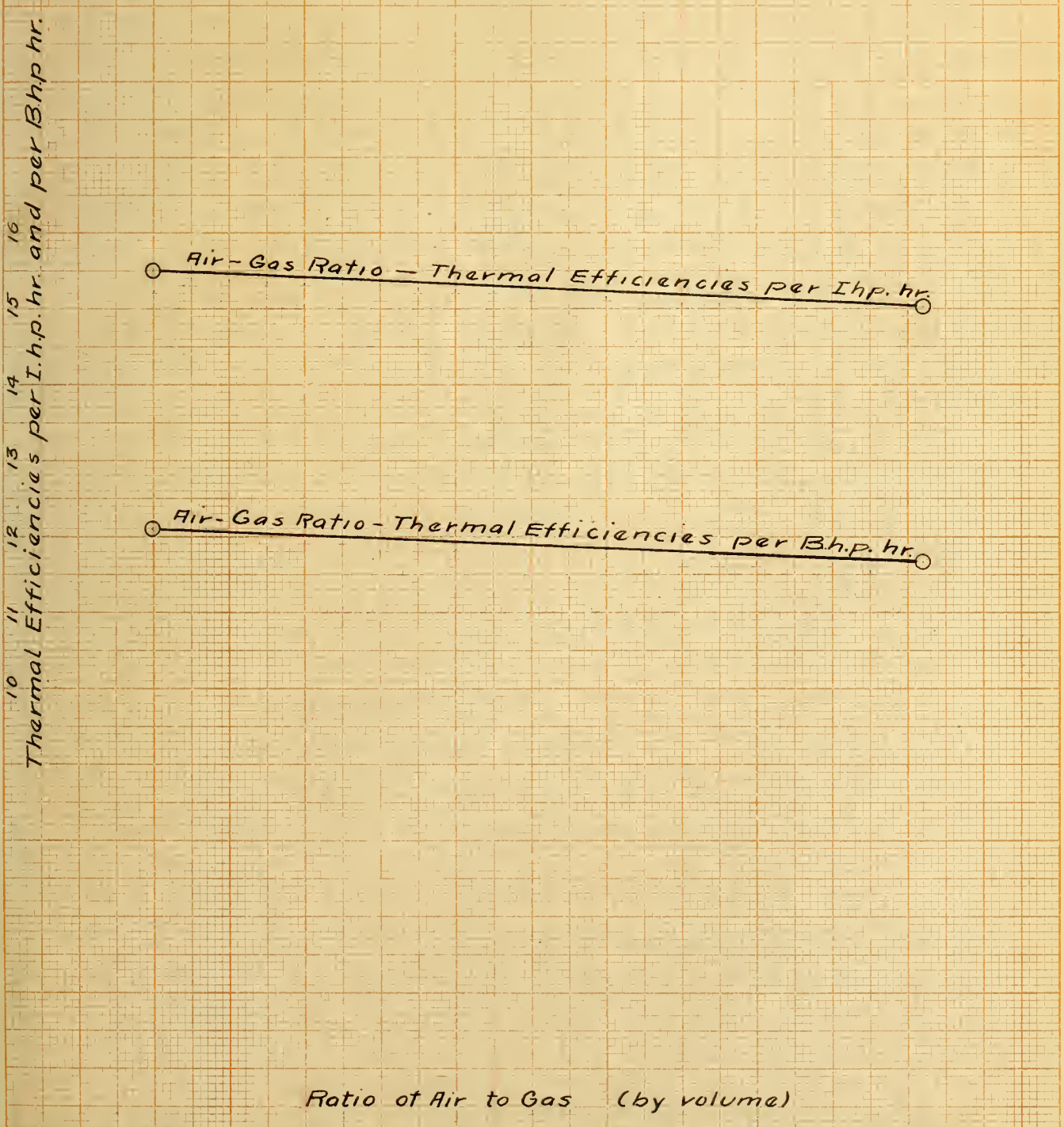


U. OF I. S. S. FORM 3

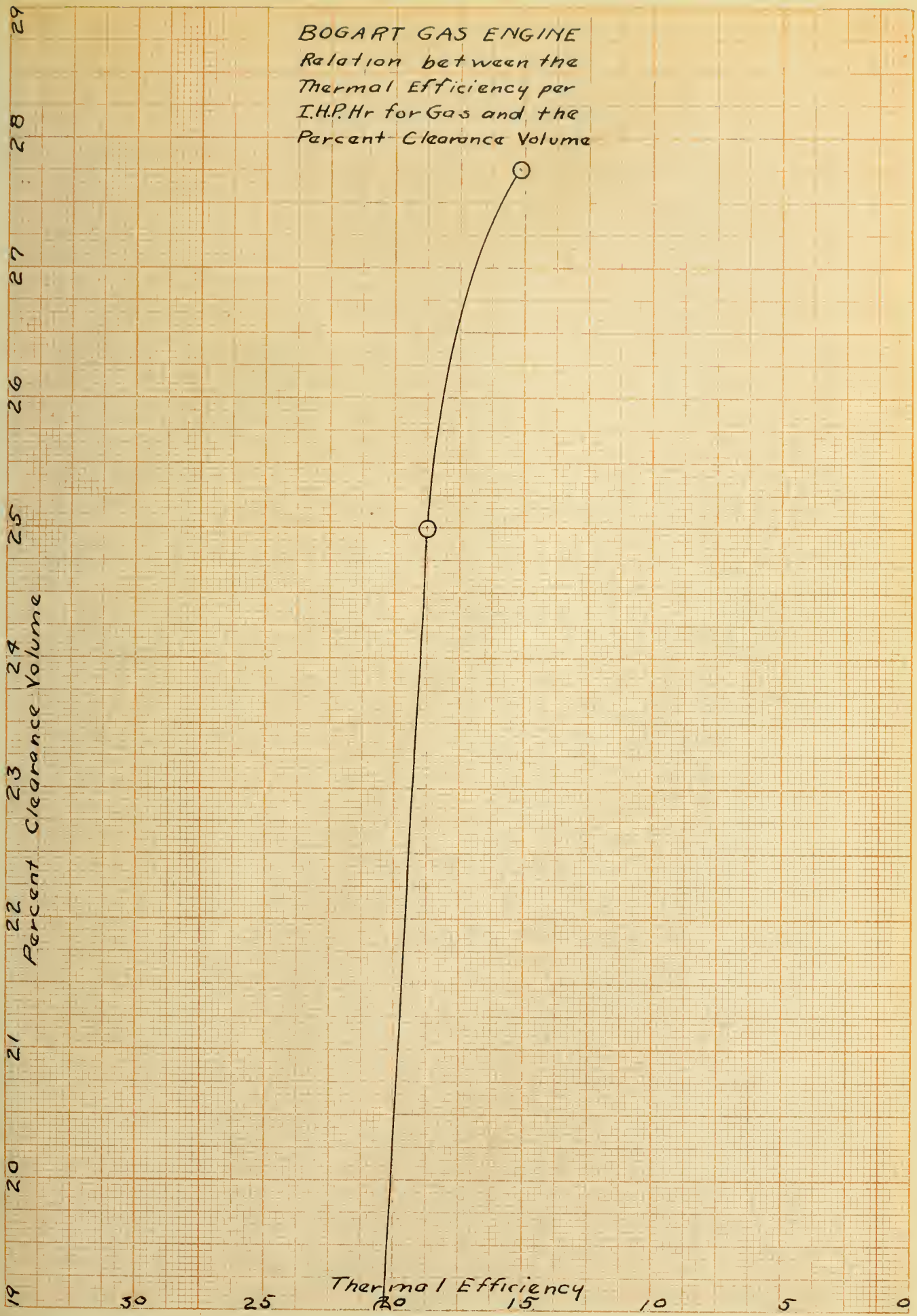
BOGART GAS ENGINE

Relation between Air to Gas Ratio (by volume) and Thermal Efficiencies per I.hp. and B.h.p. hr.

Tests 25 and 26
Clearance equals 27.76 o/o of piston displacement

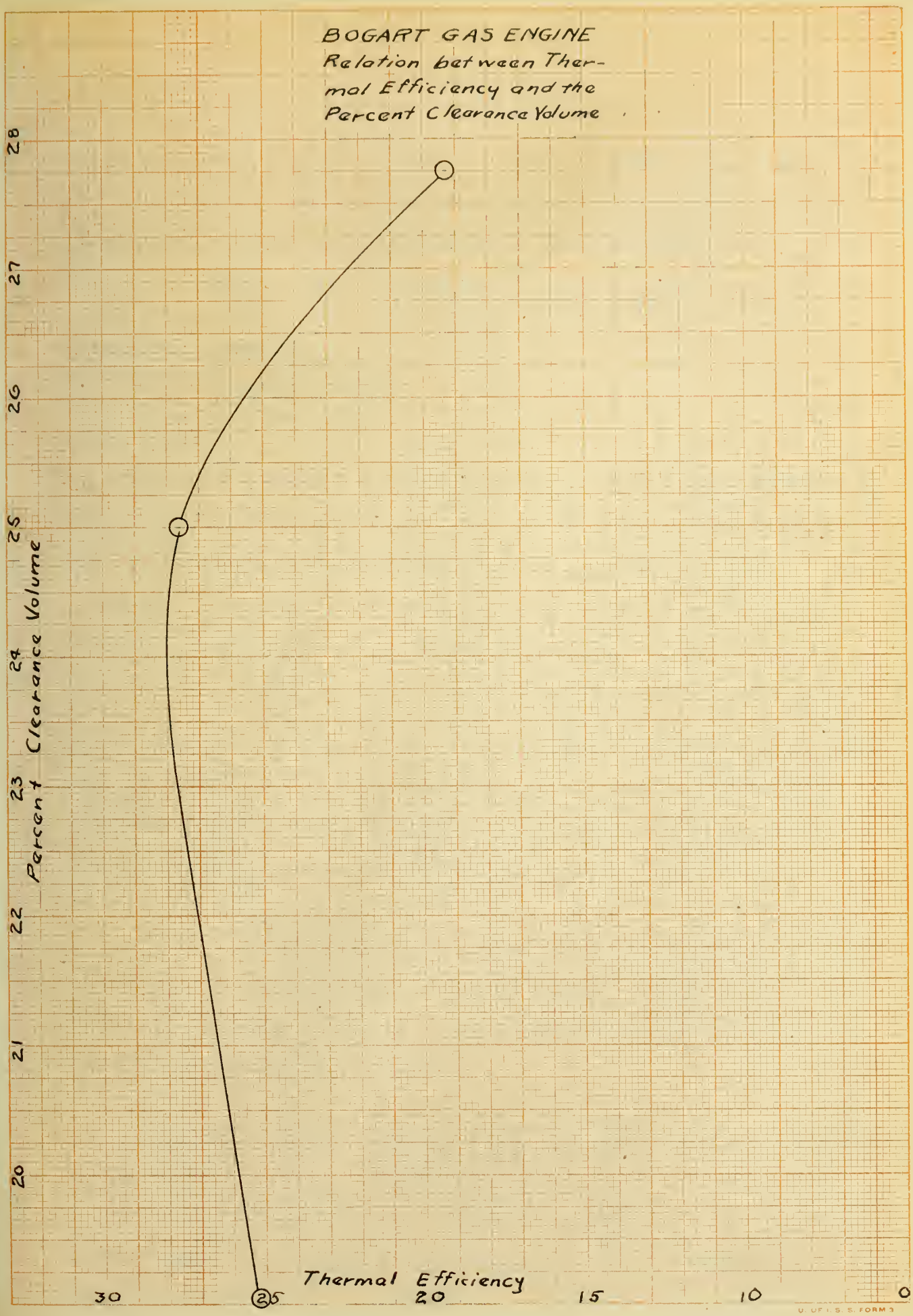


U. OF I. S. S. FORM 3



U. OF I. S. S. FORM 3

BOGART GAS ENGINE
Relation between Thermal Efficiency and the Percent Clearance Volume.



U. OF I. S. S. FORM 3

13. Calculations.- The reduction of the gas volume as measured to the standard condition of 62. degrees F. and 14.7 pounds per square inch was obtained by the formula -

$$\frac{PsVs}{Ts} = \frac{PV}{T}$$ in which the subscript s refers to standard conditions.

$$\text{Thus } Vs = \frac{PVTs}{TPs}$$

The gas pressure was determined by adding the pressure of the gas in pounds per square inch to the atmosphere pressure as determined by the barometer. The gas pressure was measured in inches of kerosene. The ratio of the specific gravity of kerosene at the room temperature to the specific gravity of water was used in reducing the pressure in inches of kerosene to inches of water from which the pressure of the gas in pounds per square inch was determined. The absolute temperature of the gas was obtained by adding the observed gas temperature to the absolute zero temperature.

As the air was under suction, and hence below atmospheric pressure, the pressure in pounds per square inch as determined from the reading in inches of kerosene was subtracted from the observed atmospheric pressure.

The gasoline gage was calibrated with the specific gravity of gasoline at .725. The amounts of gasoline per hour were corrected by multiplying the observed amount by ratio of the observed specific gravity as determined with a hydrometer to .725.

(21) The ratio of air to gas was determined from the indicator by multiplying the value of air per hour as read by eight and dividing by the gas per hour. The copper diaphragm thru which the air passes contains eight holes and is, therefore, eight times the reading indicated.

The calorific value of the fuel were obtained from the chemist's analysis, due to the fact that the laboratory calorimeter was unavailable at the time the tests were conducted.

(28) Indicated Horse Power = $\frac{LEAP}{33000}$

in which -

L = the length of the stroke in feet

E = explosions per minute

A = area of cylinder in square inches

P = mean effective pressure.

(29) Brake Horse Power = $\frac{2\pi LWN}{33000}$ in which

L = Length of brake arm in feet

W = Load in pounds on the scales

N = Number of revolutions per minute.

(30) Friction Horse Power = I. H. P. - B. H. P.

(32) Mechanical Efficiency = $\frac{B.\ H.\ P.}{I.\ H.\ P.}$

(33) Heat units consumed by engine per I. H. P. or B. H. P. hour = heating value of the fuel x fuel per hour (std) ÷ the I. H. P. or B H. P.

(34) Pounds of fuel or cubic feet of gas consumed per I. H. P. or B. H. P. hour = quantity of fuel per hour (std) ÷ I. H. P. or B. H. P.

(35) Thermal efficiency ratio per I. H. P. or B. H. P hour = 2545 divided by the heat units consumed by the engine per I. H. P. or B. H. P hour.

(36) Work done per heat unit = Thermal efficiency x 778 foot pounds.

(37) Heat balance per I. H. P. hour

(a) Heat conveyed into work = 2545 B. T. U.

(b) Heat rejected to cooling water = (22a) (17aII - 17aI) + (22b) (17bII - 17bI)

(c) Heat rejected to exhaust gases = (23) (18b-18a)

(d) Heat unaccounted for, including radiation = 33a - (37 a + 37b + 37c)

(38) Per cent of heat distribution.

(a) Heat conveyed into work = 37 a ÷ 37e.

(b) Heat rejected to cooling water = 37 b ÷ 37 e

(c) Heat rejected to exhaust gases = 37 c ÷ 37 e

(d) Heat unaccounted for, including radiation = 37 d ÷ 37 e.

DATA AND RESULTS OF THE TEST OF A BOGART GAS ENGINE.

(1) Test of a Bogart Gas Engine, located at the University of Illinois.to determine. the efficiencies under variable..... water jacket temperatures.....Conducted by

(2) Type of engine.....Horizontal Gas.

(3) Class of Engine.....Stationary.

(4) Class of Cycle.....Four Cycle.

(5) Method of Ignition.....Make & Break.

(6) Name of Builder.....Bogart Power Engineering Co Buffalo, N.Y.

(7) Dimensions.....

(a) Class of Cylinder.....Single Cylinder, Single Acting.

(b) Diameter of Cylinder.....10 inches.

(c) Stroke of Piston..... 9 inches.

(d) Compression space..... 19.04%

(e) Governing.....Throttling.

(f) Horse power constant for 1 lb.m.e.p. and 1 r.p.m. ..... .0008925

(8) Rated Capacity.....15 Horse Power.

(9) Date..... April 15, 1913.

(10) Duration of Tests..... ½ Hrs.

(11) Kind of Fuel..... City Gas

(12) Heating Properties of Fuel.....650 B.t.u. per cu. Ft.

AVERAGE PRESSURES AND TEMPERATURES.

(13) Barometer Pressure.....(in.Hg.)	29.212	29.212	29.212	29.212	29.212	29.212
(14) Temp. of Gas at Meter....(°F)	66.15	65.30	64.6	65	63.4	66.3
(15) Pressure of Gas at Meter.($in H_2O$)	4.23	4.37	3.11	3.57	4.85	4.2
(16) Temp. of Air.....(°F)	68.15	66	56	56	58.6	65.3
(17) Temp. of Cooling Water.....						
(a) thru cylinder head.....						
I. Inlet.....(°F)	61	64	64	64	61.7	61
II. Outlet.....(°F)	72	90	112.7	131.4	148	172.6

(b) Thru cylinder jacket.

I. Inlet °(°F)
II. Outlet. (°F)

(18) Temperature of Calorimeter water.
a. Inlet
b. Outlet

(19) Fuel consumed (std). cu.ft. ....

(20) Air supplied (std). cu.ft. ....

(21) Ratio of Air to Gas (by Volume)

(22) Cooling water (weight) per hr
a. Thru cylinder head.
b. Thru cylinder jacket.

(23) Calorimeter water (weight)

(24) Calorific value of oil per lb. or per cu. ft. gas by cal. test. (B.t.u.)

(25) Mean Effective Pressure

(26) Revolutions per minute.

(27) Explosions per minute.

POWER

(28) Indicated Horsepower.

(29) Brake Horsepower.

(30) Friction Horsepower.

(31) Percentage of I.H.P. lost in friction.

(32) Mechanical efficiency.

ECONOMY RESULTS

(33) Heat units consumed by engine per hour.
a. Per. I.H.P.
b. Per. B.H.P.

(34) Pounds of fuel or cu. ft. of gas consumed per
a. I.H.P. hr.
b. B.H.P. hr.

61.0	69.0	64.0	69.0	61.7	61
75.7	89.65	109.3	128	154	176.1
62.55	62.85	63.00	63.00	61.30	60.00
100.3	100.15	98.15	98.00	96.60	94.30
2526	248.2	248	246.2	248.2	250
1815	1800	1821	1810	1810	1800
6.795	6.73	6.731	6.860	6.980	6.896
2108	584	350	238	200	134
3140	1508	886	580	408	280
842	890	942	954	968	972
650	650	650	650	650	650
51.4	50.15	52.1	51.5	52.5	51.0
268	269	269.9	268	266	264
134	134.5	134.95	134	133	134
12.30	12.01	12.65	12.31	12.51	12.03
9.112	9.146	9.248	9.112	9.078	8.976
3.188	2.864	3.402	3.198	3.432	3.054
25.9	23.8	26.9	25.9	27.4	25.5
74.1	76.0	73.0	74.0	72.5	74.5
13,500	13,550	12,850	13,090	13,050	13,980
18,310	17,830	17,600	17,690	18,020	18,720
20.78	20.82	19.78	20.12	20.04	20.94
28.02	27.42	27.04	27.20	27.68	28.80

(35) Thermal efficiency ratio

a. Per I.H.P.
b. Per B.H.P.

(36) Work done per heat unit. Ft. lb. of work per B.t.u. consumed.

(37) Heat balance on B.t.u. per I.H.P. hr.

a. Heat conveyed into work
b. Heat rejected in cooling water.
c. Heat rejected in exhaust gases.
d. Heat unaccounted for including radiation.
e. Total heat consumed per I.H.P. hr.

(38) Percent of Heat Distribution

a. Heat conveyed into work
b. Heat rejected in cooling water.
c. Heat rejected in exhaust gases.
d. Heat unaccounted for including radiation.
e. Total heat consumed per I.H.P. hr.

18.89	18.45	19.80	19.52	19.50	18.71
13.98	14.40	14.47	14.39	14.13	13.95
108.9	112.0	112.5	112.0	110.0	108.5
2545	2545	2545	2545	2545	2545
5210	4370	4500	4300	4480	3920
2590	2740	2610	2710	2780	2775
3155	3785	3195	3545	3295	4270
13,500	13,440	12,850	13,100	13,050	13,610
18.87	18.95	19.80	19.50	19.50	18.75
38.57	32.51	35.05	32.90	33.40	28.87
19.20	20.40	20.30	20.73	21.32	20.40
23.36	28.14	24.85	26.87	25.78	31.98
100.00	100.00	100.00	100.00	100.00	100.00

(b) Thru cylinder jacket.						
I. Inlet	57.5	58.3	59	59		
II. Outlet.	112	114	107	1124		
(18) Temperature of Calorimeter water.						
a. Inlet	57.5	58.3	59.0	59.7		
b. Outlet	91.5	90.0	98.3	91		
(19) Fuel consumed (std). (Cu.ft.)..	300.2	264	238.6	230.1		
(20) Air supplied (std).....	1760	1800	1810	1830		
(21) Ratio of Air to Gas (by Volume)	6.02	6.46	7.14	7.65		
(22) Cooling water (weight)						
a. Thru cylinder head.	358	242	298	254		
b. Thru cylinder jacket.	718	710	874	818		
(23) Calorimeter water (weight)	956	928	806	1060		
(24) Calorific value of oil per lb. or per cu. ft. gas by cal. test.	650	650	650	650		
(25) Mean Effective Pressure	49.11	49.7	49.73	49.72		
(26) Revolutions per minute.	258.6	264	259	274		
(27) Explosions per minute.	129.3	132	129.5	137		
POWER						
(28) Indicated Horsepower.	11.32	11.72	11.51	12.26		
(29) Brake Horsepower.	8.80	8.98	8.82	9.25		
(30) Friction Horsepower.	2.52	2.74	2.69	2.95		
(31) Percentage of I.H.P. lost in friction.	22.2	23.3	23.35	24.2		
(32) Mechanical efficiency.						
ECONOMY RESULTS						
(33) Heat units consumed by engine per hour.	17220	14620	13980	12280		
a. Per. I.H.P.						
b. Per. B.H.P.	22200	19100	17600	16200		
(34) Pounds of fuel or cu. ft. of gas consumed per						
a. I.H.P. hr.	26.55	22.5	20.6	18.9		
b. B.H.P. hr.	34.2	29.4	27.1	24.9		

(35) Thermal efficiency ratio

a. Per I.H.P.
b. Per B.H.P.

(36) Work done per heat unit.
Ft. lb. of work per B.t.u. consumed.

(37) Heat balance on B.t.u. per I.H.P. hr.

a. Heat conveyed into work
b. Heat rejected in cooling water.
c. Heat rejected in exhaust gases.
d. Heat unaccounted for including radiation.
e. Total heat consumed per I.H.P. hr.

(38) Percent of Heat Distribution

a. Heat conveyed into work
b. Heat rejected in cooling water.
c. Heat rejected in exhaust gases.
d. Heat unaccounted for including radiation.
e. Total heat consumed per I.H.P. hr.

14.78	17.40	18.89	20.70		
11.45	13.31	14.46	15.70		
89.1	103.8	11.38	12.22		
2550	2540	2550	2540		
4780	4550	4900	4780		
2865	2530	2750	2740		
7025	5000	3280	2170		
17220	14620	13480	12280		
14.80	17.35	18.90	20.65		
27.70	31.10	36.40	39.10		
16.60	17.30	20.40	22.30		
40.90	34.25	24.30	17.95		
100.00	100.00	100.00	100.00		

DATA AND RESULTS OF THE TEST OF A BOGART GAS ENGINE.

(1) Test of a Bogart Gas Engine, located at the University of Illinois.to determine..the efficiencies..with..varible.... ..mixture.....Conducted by

(2) Type of engine.....Horizontal Gas.

(3) Class of Engine.....Stationary.

(4) Class of Cycle.....Four Cycle.

(5) Method of Ignition.....Make & Break.

(6) Name of Builder.....Bogart Power Engineering Co Buffalo, N.Y.

(7) Dimensions..10" x 9".....

(a) Class of Cylinder.....Single Cylinder, Single Acting.

(b) Diameter of Cylinder.....10 inches.

(c) Stroke of Piston..... 9 inches.

(d) Compression space..... 19.04 %

(e) Governing.....Throttling.

(f) Horse power constant for 1 lb.m.e.p. and 1 r.p.m. ..... .0008925

(8) Rated Capacity.....15 Horse Power.

(9) Date....April 7, 1913.....

(10) Duration of Tests..... ½ Hrs.

(11) Kind Of Fuel..City Gas.....

(12) Heating Properties of Fuel.....650 B.t.u.

AVERAGE PRESSURES AND TEMPERATURES.

(13) Barometer Pressure.....	29.212 "Hg					
(14) Temp.of Gas at Meter..°F..	70.4	71	72	75.7		
(15) Pressure of Gas at Meter in. Wat.	4.71	4.57	4.57	5.0		
(16) Temp.of Air.....(°F)	63.5	63.5	64	73.4		
(17) Temp.of Cooling Water.....						
(a)thru cylinder head.....						
I.Inlet...(°F)...	57.5	58.3	59	59		
II.Outlet..(°F)...	103	115	107.5	117		

DATA AND RESULTS OF THE TEST OF A BOGART GAS ENGINE.

(1) Test of a Bogart Gas Engine, located at the University of Illinois.to determine..the efficiencies with varible.....ignition.....Conducted by

(2) Type of engine.....Horizontal Gas.

(3) Class of Engine.....Stationary.

(4) Class of Cycle.....Four Cycle.

(5) Method of Ignition.....Make & Break.

(6) Name of Builder.....Bogart Power Engineering Co Buffalo, N.Y.

(7) Dimensions.....

(a) Class of Cylinder.....Single Cylinder, Single Acting.

(b) Diameter of Cylinder.....10 inches.

(c) Stroke of Piston..... 9 inches.

(d) Compression space..... 19.04 o/o

(e) Governing.....Throttling.

(f) Horse power constant for 1 lb.m.e.p. and 1 r.p.m. 0008925

(8) Rated Capacity.....15 Horse Power.

(9) Date..... April 12, 1913

(10) Duration of Tests....one-half.... Hrs.

(11) Kind Of Fuel..... City Gas

(12) Heating Properties of Fuel..... 650 Btu.

AVERAGE PRESSURES AND TEMPERATURES.

(13) Barometer Pressure.....	29.421 "Hg					
(14) Temp.of Gas at Meter....°F.	65.4	66	66	74.3	72.4	70.4
(15) Pressure of Gas at Meter. in Ker	3.03	2.85	3.90	3.77	4.34	4.92
(16) Temp.of Air.....(°F).	58	58.2	58.5	63	61.7	61.3
(17) Temp.of Cooling Water.....						
(a)thru cylinder head.....						
I.Inlet.....(°F)	68	62	67.4	59.3	66	67
II.Outlet....(°F)	126	135.6	129	121.6	120	128.2

(b) Thru cylinder jacket.						
I. Inlet	68	62	67.4	59.3	65.3	66.5
II. Outlet.	125.4	135.6	133.4	126.6	126	113
(18) Temperature of Calorimeter water.						
a. Inlet	68	62.4	68	59.4	66	67
b. Outlet	103	94	105.5	98	104	101.6
(19) Fuel consumed (std).....	261.8	248.9	257.1	242.6	252.9	260.3
(20) Air supplied (std).....	1765	1753	1753	1798	1760	1800
(21) Ratio of Air to Gas (by Volume)	6.4	6.5	6.48	6.55	6.54	6.56
(22) Cooling water (weight)						
a. Thru cylinder head.	246	206	240	234	262	218
b. Thru cylinder jacket.	668	518	590	572	616	808
(23) Calorimeter water (weight)	902	878	804	868	866	1012
(24) Calorific value of ~~oil~~ ~~per~~ ~~lb.~~ ~~or~~ per cu. ft. gas by cal. test.	650	650	650	650	650	650
(25) Mean Effective Pressure	50.16	49.94	50.80	52.36	55.47	55.14
(26) Revolutions per minute.	258	248.6	256	253.2	244.6	240.7
(27) Explosions per minute.	129	124.3	128	126.6	122.3	120.3
POWER						
(28) Indicated Horsepower.	11.55	11.10	11.62	11.82	12.10	11.85
(29) Brake Horsepower.	8.78	8.46	8.71	8.60	8.33	8.20
(30) Friction Horsepower.	2.77	2.64	2.91	3.22	3.77	3.65
(31) Percentage of I.H.P. lost in friction.	24.0	23.8	25.0	27.4	31.2	30.8
(32) Mechanical efficiency.	76.0	76.2	75.0	72.6	68.8	69.2
ECONOMY RESULTS						
(33) Heat units consumed by engine per hour.						
a. Per. I.H.P.	14750	14560	14360	13320	13780	14280
b. Per. B.H.P.	19340	19100	19180	18350	20020	20610
(34) Pounds of fuel or cu. ft. of gas consumed per						
a. I.H.P. hr.	22.65	22.4	22.1	20.52	21.25	22.0
b. B.H.P. hr.	29.8	29.4	29.5	28.2	30.9	31.8

(35) Thermal efficiency ratio

a. Per I.H.P.
b. Per B.H.P.

(36) Work done per heat unit.
Ft. lb. of work per B.t.u. consumed.

(37) Heat balance on B.t.u. per I.H.P. hr.

a. Heat conveyed into work
b. Heat rejected in cooling water.
c. Heat rejected in exhaust gases.
d. Heat unaccounted for including radiation.
e. Total heat consumed per I.H.P. hr.

(38) Percent of Heat Distribution

a. Heat conveyed into work
b. Heat rejected in cooling water.
c. Heat rejected in exhaust gases.
d. Heat unaccounted for including radiation.
e. Total heat consumed per I.H.P. hr.

17.25	17.37	17.72	19.10	18.50	17.80
13.30	13.31	13.29	13.85	12.70	12.33
103.5	103.6	103.4	107.9	99.00	96.1
2545	2545	2545	2545	2545	2545
4650	4840	4630	4490	4280	4700
2735	2500	2556	2838	2720	2960
4820	4675	4629	3947	4235	4075
14750	14560	14360	13320	13780	14280
17.25	17.49	17.70	19.10	18.48	17.82
31.50	33.20	32.20	33.75	31.10	32.90
18.50	17.18	17.78	21.25	19.72	20.70
32.75	32.13	32.32	25.90	30.70	28.58
100.00	100.00	100.00	100.00	100.00	100.00

DATA AND RESULTS OF THE TEST OF A DOGART GAS ENGINE.

(1) Test of a Dogart Gas Engine, located at the University of Illinois.to determine..the..efficiencies..with..varible.... ..mixture.....Conducted by

(2) Type of engine.....Horizontal Gas.

(3) Class of Engine.....Stationary.

(4) Class of Cycle.....Four Cycle.

(5) Method of Ignition.....Make & Break.

(6) Name of Builder.....Dogart Power Engineering Co Buffalo, N.Y.

(7) Dimensions.....

(a) Class of Cylinder.....Single Cylinder, Single Acting.

(b) Diameter of Cylinder.....10 inches.

(c) Stroke of Piston..... 9 inches.

(d) Compression space.....19.04 o/o

(e) Governing.....Throttling.

(f) Horse power constant for 1 lb.m.e.p. and 1 r.p.m. ..... = .0008925

(8) Rated Capacity.....15 Horse Power.

(9) Date...April.19.1913.....

(10) Duration of Tests..one-half..... Hrs.

(11) Kind Of Fuel..Gasoline.....

(12) Heating Properties of Fuel.....19740 B.t.u.

AVERAGE PRESSURES AND TEMPERATURES.

(13) Barometer Pressure..29.592"..						
(14) Temp.of Gas at Meter.....						
(15) Pressure of Gas at Meter...						
(16) Temp.of Air.....(°F)...	62.4	64.4	66.2			
(17) Temp.of Cooling Water.....						
(a)thru cylinder head.....						
I.Inlet.....(°F)...	60	58.3	63.4			
II.Outlet..(°F)..	114	116.4	119			

(b) Thru cylinder jacket.						
I. Inlet (°F)	60	58.3	63.4			
II. Outlet. (°F)	118.3	121.3	117.8			
(18) Temperature of Calorimeter water.						
a. Inlet	63	58.3	63			
b. Outlet	112.2	99.8	107.7			
(19) Fuel consumed (lbs.).....	10.76	9.54	8.12			
(20) Air supplied (lbs.).....	2240	2290	2214			
(21) Ratio of Air to Gas (by Volume)						
(22) Cooling water (weight)						
a. Thru cylinder head.	236	238	266			
b. Thru cylinder jacket.	644	592	858			
(23) Calorimeter water (weight)	788	1026	490			
(24) Calorific value of oil per lb. or per cu. ft. gas by cal. test.	19740	19740	19740			
(25) Mean Effective Pressure	61.6	56.6	57.0			
(26) Revolutions per minute.	293.4	304.6	312.7			
(27) Explosions per minute.	146.7	152.6	156.4			
POWER						
(28) Indicated Horsepower.	16.11	15.41	15.90			
(29) Brake Horsepower.	10.72	11.17	11.47			
(30) Friction Horsepower.	5.39	4.24	4.43			
(31) Percentage of I.H.P. lost in friction.	33.4	27.4	27.9			
(32) Mechanical efficiency.	66.6	72.4	72.0			
ECONOMY RESULTS						
(33) Heat units consumed by engine per hour.						
a. Per. I.H.P.	13,190	12,210	10,100			
b. Per. B.H.P.	19,800	16,900	14,020			
(34) Pounds of fuel or cu. ft. of gas consumed per						
a. I.H.P. hr.	.6682	.618	.5108			
b. B.H.P. hr.	1.002	.8550	.710			

(35) Thermal efficiency ratio

a. Per I.H.P.
b. Per B.H.P.

(36) Work done per heat unit. Ft. lb. of work per B.t.u. consumed.

(37) Heat balance on B.t.u. per I.H.P. hr.

a. Heat conveyed into work
b. Heat rejected in cooling water.
c. Heat rejected in exhaust gases.
d. Heat unaccounted for including radiation.
e. Total heat consumed per I.H.P. hr.

(38) Percent of Heat Distribution

a. Heat conveyed into work
b. Heat rejected in cooling water.
c. Heat rejected in exhaust gases.
d. Heat unaccounted for including radiation.
e. Total heat consumed per I.H.P. hr.

19.31	20.8	25.2			
12.85	15.08	18.15			
100.0	117.3	141.1			
2,545	2,545	2,545			
2939	3,190	3,861			
2,908	2,761	2,758			
5,303	3714	9360			
13,195	12,210	10,100			
19.34	20.80	25.20			
22.23	26.10	38.22			
18.23	22.60	27.13			
40.20	30.50	9.45			
100.00	100.00	100.00			

DATA AND RESULTS OF THE TEST OF A BOGART GAS ENGINE.

(1) Test of a Bogart Gas Engine, located at the University of Illinois.to determine..the efficiencies....with.....
...varible..mixture.....Conducted by

(2) Type of engine.....Horizontal Gas.

(3) Class of Engine.....Stationary.

(4) Class of Cycle.....Four Cycle.

(5) Method of Ignition.....Make & Break.

(6) Name of Builder.....Bogart Power Engineering Co Buffalo, N.Y.

(7) Dimensions.....

(a) Class of Cylinder.....Single Cylinder, Single Acting.

(b) Diameter of Cylinder.....10 inches.

(c) Stroke of piston..... 9 inches.

(d) Compression space..... 25%

(e) Governing.....Throttling.

(f) Horse power constant for 1 lb.m.e.p. and 1 r.p.m. ..... .0008925

(8) Rated Capacity.....15 Horse Power.

(9) Date..... April 21, 1913

(10) Duration of Tests....one-half.... Hrs.

(11) Kind of Fuel.....City Gas.....

(12) Heating Properties of Fuel.....650 B.t.u.

AVERAGE PRESSURES AND TEMPERATURES.

(13) Barometer Pressure..29.49..	29.32					
(14) Temp.of Gas at Meter.....	88	88				
(15) Pressure of Gas at Meter...	4.06	4.2				
(16) Temp.of Air.....(°F)..	83.7	83.6				
(17) Temp.of Cooling Water.....						
(a)thru cylinder head.....						
I.Inlet....(°F)	60.4	61.8				
II.Outlet...(°F)..	132.7	134				

(b) Thru cylinder jacket.						
I. Inlet (°F)	120.8	123.6				
II. Outlet. (°F)	257.2	266.2				
(18) Temperature of Calorimeter water.						
a. Inlet	112.2	123.6				
b. Outlet	214.6	198.6				
(19) Fuel consumed (std).....	270.2	270.2				
(20) Air supplied (std).....	1965	1992				
(21) Ratio of Air to Gas (by Volume)	6.47	7.04				
(22) Cooling water (weight)	~~190~~	~~220~~				
a. Thru cylinder head.	190	220				
b. Thru cylinder jacket.	594	614				
(23) Calorimeter water (weight)	942	938				
(24) Calorific value of oil per lb. or per cu. ft. gas by cal. test.	650	650				
(25) Mean Effective Pressure	53.3	52.2				
(26) Revolutions per minute.	261.1	261.1				
(27) Explosions per minute.	130.5	130.5				
POWER						
(28) Indicated Horsepower.	12.81	12.19				
(29) Brake Horsepower.	8.88	8.88				
(30) Friction Horsepower.	3.93	3.31				
(31) Percentage of I.H.P. lost in friction.	30.7	27.1				
(32) Mechanical efficiency.	69.2	73.0				
ECONOMY RESULTS						
(33) Heat units consumed by engine per hour.						
a. Per. I.H.P.	13700	14410				
b. Per. B.H.P.	19800	19800				
(34) Pounds of fuel or cu. ft. of gas consumed per						
a. I.H.P. hr.	21.1	22.2				
b. B.H.P. hr.	30.5	30.5				

(35) Thermal efficiency ratio

a. Per I.H.P.
b. Per B.H.P.

(36) Work done per heat unit.
Ft. lb. of work per B.t.u. consumed.

(37) Heat balance on B.t.u. per I.H.P. hr.

a. Heat conveyed into work
b. Heat rejected in cooling water.
c. Heat rejected in exhaust gases.
d. Heat unaccounted for including radiation.
e. Total heat consumed per I.H.P. hr.

(38) Percent of Heat Distribution

a. Heat conveyed into work
b. Heat rejected in cooling water.
c. Heat rejected in exhaust gases.
d. Heat unaccounted for including radiation.
e. Total heat consumed per I.H.P. hr.

18.6	17.65				
12.85	12.85				
99.2	99.2				
2545	2545				
4341	4880				
2920	3110				
3894	3875				
13700	14410				
18.55	17.65				
31.6	33.8				
21.3	21.55				
28.4	26.9				
100	100				

20 - 21 mc.

DATA AND RESULTS OF THE TEST OF A BOGART GASOLINE.

(1) Test of a Bogart Gas Engine, located at the University of Illinois.to determine..the..efficiencies..with.variable.mixture .....Conducted by

(2) Type of engine.....Horizontal Gas.

(3) Class of Engine.....Stationary.

(4) Class of Cycle.....Four Cycle.

(5) Method of Ignition.....Make & Break.

(6) Name of Builder.....Bogart Power Engineering Co Buffalo, N.Y.

(7) Dimensions....10"x8".....

(a) Class of Cylinder.....Single Cylinder, Single Acting.

(b) Diameter of Cylinder.....10 inches.

(c) Stroke of Piston..... 9 inches.

(d) Compression space...25%.....

(e) Governing.....Throttling.

(f) Horse power constant for 1 lb.m.e.p. and 1 r.p.m. ..... .0008925

(8) Rated Capacity.....15 Horse Power.

(9) Date...April.23.1913.....

(10) Duration of Tests.....½..... Hrs.

(11) Kind Of Fuel...Gasoline.....

(12) Heating Properties of Fuel..19740 B.T.U.

AVERAGE PRESSURES AND TEMPERATURES.

(13) Barometer Pressure.....	29.432" Hg.					
(14) Temp.of Gas at Meter.....						
(15) Pressure of Gas at Meter...						
(16) Temp.of Air.....(°F)...	76°	76.3	76.7			
(17) Temp.of Cooling Water.....						
(a)thru cylinder head.....						
I.Inlet...(°F)...	66°	67.4	68.6			
II.Outlet..(°F)...	131.4	133.	126.5			

(b) Thru cylinder jacket.						
I. Inlet (°F)	66	67.4	68.6			
II. Outlet. (°F)	128.6	128.7	139			
(18) Temperature of Calorimeter water.						
a. Inlet	66.4	68.	69.			
b. Outlet	116.2	117.4	115.7			
(19) Fuel consumed (lbs).....	10.5	9.4	6.96			
(20) Air supplied (std).....	2340.	2341.	2318.			
(21) Ratio of Air to Gas (by Volume)						
(22) Cooling water (weight)						
a. Thru cylinder head.	226.	236.	232.			
b. Thru cylinder jacket.	672.	740.	600.			
(23) Calorimeter water (weight)	874.	946.	934.			
(24) Calorific value of oil per lb. or per cu. ft. gas by cal. test.	19740.	19740.	19740.			
(25) Mean Effective Pressure	53.2	52.6	56.1			
(26) Revolutions per minute.	332.6	342.	297.4			
(27) Explosions per minute.	166.3	171.	148.7			
POWER						
(28) Indicated Horsepower.	15.8	16.07	14.9			
(29) Brake Horsepower.	11.31	11.63	10.11			
(30) Friction Horsepower.	4.49	4.44	4.79			
(31) Percentage of I.H.P. lost in friction.	28.4	27.6	32.1			
(32) Mechanical efficiency.	71.6	72.5	68.0			
ECONOMY RESULTS						
(33) Heat units consumed by engine per hour.						
a. Per. I.H.P.	13100.	11550	9230.			
b. Per. B.H.P.	18370	15940.	13600			
(34) Pounds of fuel or cu. ft. of gas consumed per						
a. I.H.P. hr.	.665	.585	.468			
b. B.H.P. hr.	.928	.808	.688			

(35) Thermal efficiency ratio

a. Per I.H.P.
b. Per B.H.P.

(36) Work done per heat unit. Ft. lb. of work per B.t.u. consumed.

(37) Heat balance on B.t.u. per I.H.P. hr.

a. Heat conveyed into work
b. Heat rejected in cooling water.
c. Heat rejected in exhaust gases.
d. Heat unaccounted for including radiation.
e. Total heat consumed per I.H.P. hr.

(38) Percent of Heat Distribution

a. Heat conveyed into work
b. Heat rejected in cooling water.
c. Heat rejected in exhaust gases.
d. Heat unaccounted for including radiation.
e. Total heat consumed per I.H.P. hr.

19.45	22.05	27.6			
13.85	16.95	18.7			
101.8	124.2	145.5			
2545	2545	2545			
3600.	3785	3530			
2760	2790	2770			
4195	2430	385			
13100	11550.	9230.			
19.09	22.02	27.6			
28.55	32.75	40.48			
21.01	24.18	31.81			
31.35	21.00	00.11			

DATA AND RESULTS OF THE TEST OF A DOGART GAS ENGINE.

(1) Test of a Dogart Gas Engine, located at the University of Illinois.to determine. The efficiencies with variable mixture.....Conducted by

(2) Type of engine.....Horizontal Gas.

(3) Class of Engine.....Stationary.

(4) Class of Cycle.....Four Cycle.

(5) Method of Ignition.....Make & Break.

(6) Name of Builder.....Dogart Power Engineering Co Buffalo, N.Y.

(7) Dimensions.....

(a) Class of Cylinder.....Single Cylinder, Single Acting.

(b) Diameter of Cylinder.....10 inches.

(c) Stroke of Piston..... 9 inches.

(d) Compression space..... 27.76 o/o

(e) Governing.....Throttling.

(f) Horse power constant for 1 lb.m.e.p. and 1 r.p.m. 0008925

(8) Rated Capacity.....15 Horse Power.

(9) Date..... April 30, 1913

(10) Duration of Tests....one-half.... Hrs.

(11) Kind of Fuel...City Gas.....

(12) Heating Properties of Fuel..... 650 B.t.u.

AVERAGE PRESSURES AND TEMPERATURES.

(13) Barometer Pressure..in. Hg.	29.51					
(14) Temp.of Gas at Meter.....	85.1	86				
(15) Pressure of Gas at Meter...	4.4	4.74				
(16) Temp.of Air.....(°F)...	81	81.3				
(17) Temp.of Cooling Water.....						
(a)thru cylinder head....(°F)						
I.Inlet.....	63.1	66.4				
II.Outlet.....	125	130				

(b) Thru cylinder jacket.						
I. Inlet (°F)	67.1	66.4				
II. Outlet. (°F)	134	127				
(18) Temperature of Calorimeter water.						
a. Inlet	66	65.3				
b. Outlet	107	109.6				
(19) Fuel consumed (std)..... Cu.ft.	280	256				
(20) Air supplied (std).....	1818	1817				
(21) Ratio of Air to Gas (by Volume)	6.00	6.51				
(22) Cooling water (weight)						
a. Thru cylinder head.	248	238				
b. Thru cylinder jacket.	606	619				
(23) Calorimeter water (weight)	890	704				
(24) Calorific value of oil per lb. or per cu. ft. gas by cal. test.	650	650				
(25) Mean Effective Pressure	48.9	49.1				
(26) Revolutions per minute.	2593	2234				
(27) Explosions per minute.	1271.5	111.7				
POWER						
(28) Indicated Horsepower.	11.10	9.80				
(29) Brake Horsepower.	8.66	7.60				
(30) Friction Horsepower.	2.44	2.20				
(31) Percentage of I.H.P. lost in friction.	22.0	22.4				
(32) Mechanical efficiency.	78.00	77.55				
ECONOMY RESULTS						
(33) Heat units consumed by engine per hour.						
a. Per. I.H.P.	16400	16950				
b. Per. B.H.P.	21,000	21,800				
(34) Pounds of fuel or cu. ft. of gas consumed per						
a. I.H.P. hr.	2520	2610				
b. B.H.P. hr.	3240	3370				

(35) Thermal efficiency ratio

a. Per I.H.P.
b. Per B.H.P.

(36) Work done per heat unit. Ft. lb. of work per B.t.u. consumed.

(37) Heat balance on B.t.u. per I.H.P. hr.

a. Heat conveyed into work
b. Heat rejected in cooling water.
c. Heat rejected in exhaust gases.
d. Heat unaccounted for including radiation.
e. Total heat consumed per I.H.P. hr.

(38) Percent of Heat Distribution

a. Heat conveyed into work
b. Heat rejected in cooling water.
c. Heat rejected in exhaust gases.
d. Heat unaccounted for including radiation.
e. Total heat consumed per I.H.P. hr.

15.50	15.01				
12.10	11.68				
94.10	90.90				
25,500	25,520				
49,400	52,500				
31,990	31,800				
57.160	59,680				
164,000	169,500				
15.53	15.03				
30.20	30.00				
19.45	18.75				
34.80	36.22				
100.00	100.00				

DATA AND RESULTS OF THE TEST OF A BOGART GAS ENGINE.

(1) Test of a Bogart Gas Engine, located at the University of Illinois.to determine..the efficiencies..with..... ..variable..mixture.....Conducted by

(2) Type of engine.....Horizontal Gas.

(3) Class of Engine.....Stationary.

(4) Class of Cycle.....Four Cycle.

(5) Method of Ignition.....Make & Break.

(6) Name of Builder.....Bogart Power Engineering Co Buffalo,N.Y.

(7) Dimensions.....

(a) Class of Cylinder.....Single Cylinder, Single Acting.

(b) Diameter of Cylinder.....10 inches.

(c) Stroke of Piston..... 9 inches.

(d) Compression space...27.76%..

(e) Governing.....Throttling.

(f) Horse power constant for 1 lb.m.e.p. and 1 r.p.m. 0009825

(8) Rated Capacity.....15 Horse Power.

(9) Date.....May.2.1913.....

(10) Duration of Tests..... Hrs.

(11) Kind of Fuel.....Gasoline.....

(12) Heating Properties of Fuel..19740.

AVERAGE PRESSURES AND TEMPERATURES.

(13) Barometer Pressure.....	29.353" Hg.					
(14) Temp.of Gas at Meter.....						
(15) Pressure of Gas at Meter...						
(16) Temp.of Air.....(°F)	87.8					
(17) Temp.of Cooling Water.....						
(a)thru cylinder head.....						
I.Inlet.....(°F).	65.4					
II.Outlet...(°F).	137.3					

(b) Thru cylinder jacket.						
I. Inlet (°F)	65.4					
II. Outlet. (°F)	127.1					
(18) Temperature of Calorimeter water.						
a. Inlet (°F)	65.4					
b. Outlet (°F)	108.7					
(19) Fuel consumed (lbs).....	9.9					
(20) Air supplied (std).....	2.190					
(21) Ratio of Air to Gas (by Volume)						
(22) Cooling water (weight)						
a. Thru cylinder head.	182.					
b. Thru cylinder jacket.	658.					
(23) Calorimeter water (weight)	935.					
(24) Calorific value of oil per lb. or per cu. ft. gas by cal. test.	19470.					
(25) Mean Effective Pressure	50.8					
(26) Revolutions per minute.	292.4					
(27) Explosions per minute.	146.2					
POWER						
(28) Indicated Horsepower.	13.3					
(29) Brake Horsepower.	9.95					
(30) Friction Horsepower.	3.35					
(31) Percentage of I.H.P. lost in friction.	25.2					
(32) Mechanical efficiency.	74.8					
ECONOMY RESULTS						
(33) Heat units consumed by engine per hour.						
a. Per. I.H.P.	132.00					
b. Per. B.H.P.	17680.					
(34) Pounds of fuel or cu. ft. of gas consumed per						
a. I.H.P. hr.	.744					
b. B.H.P. hr.	995					

(35) Thermal efficiency ratio

a. Per I.H.P.
b. Per B.H.P.

(36) Work done per heat unit.
Ft. lb. of work per B.t.u. consumed.

(37) Heat balance on B.t.u. per I.H.P. hr.

a. Heat conveyed into work
b. Heat rejected in cooling water.
c. Heat rejected in exhaust gases.
d. Heat unaccounted for including radiation.
e. Total heat consumed per I.H.P. hr.

(38) Percent of Heat Distribution

a. Heat conveyed into work
b. Heat rejected in cooling water.
c. Heat rejected in exhaust gases.
d. Heat unaccounted for including radiation.
e. Total heat consumed per I.H.P. hr.

19.3					
14.4					
112.					
2545					
4040.					
3050					
3565					
13200					
19.3					
30.5					
23.1					
27.1					
100.0					

14.- Conclusions. - Due to inaccurate information concerning the rated speed of the engine, the load carried by the gas engine was greater than allowable to maintain the rated speed. The determination of the load however, in the preliminary experiments, showed that the load used produced a maximum horse-power.

The mechanical efficiencies obtained thruout the various tests are average, and show the engine to have been working efficiently with regard to the load carried.

The thermal efficiencies per I. H. P. and B. H. P. hour are lower than obtained in ordinary practice, and may be accounted for, undoubtedly, by the leakage from the engine cylinder. The full heating value of the fuel is not utilized when leakage occurs, inasmuch as the quantity of fuel in the cylinder at the end of compression and explosion is reduced considerably, thus the quantity actually used in producing work is much less than is accounted for at the end of the suction stroke. Hence, with low compression and explosion pressures, the mean effective pressures obtained were low, with a consequent reduction of the indicated and brake horse-power and an increase in the consumption of gas or gasoline per I. H. P. or B. H. P. hour.

The heat balance shows some interesting results, namely, that as the air - gas ratio or the air - gasoline ratio increases, the heat generated per cubic foot or pound of fuel,

becomes more nearly accounted for. This fact is apparent from a consideration of the heat units per unit volume of mixture. As the proportion of air increases, the heating value per cubic foot decreases. In consequence, the temperatures obtained are lower and the exposed surfaces much cooler. Hence the heat taken up by the jacket and calorimeter waters was in a greater proportion to the heat generated than in the tests where a richer mixture was used.

In conclusion, the engine worked fairly efficiently and if the piston rings were renewed, the rated horse-power and excellent efficiencies would undoubtedly be obtained.

LOG SHEET FOR BO'GART GAS ENGINE TEST

TEST No. 1

Date April 5, 1913
Barometer 29.212 in. Hg. Room Temp. 74°F.
Fuel City Gas Density
Clearance Volume 19.04 %
Conditions of Test Variable Jacket Water

TEST No. 2

Date April 5, 1913
Barometer 29.212 in. Hg. Room Temp 74°F.
Fuel City Gas Density
Clearance Volume 19.04 %
Conditions of Test Variable Jacket Water

ITEM	0	5	10	15	20	25	30	AV.	0	5	10	15	20	25	30	AV.
R.P.M.	266	270	264	264	272	272	270	268	274	272	270	266	266	272	266	269
Wt. on Scale (Lbs)	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65
Meter (Cu.Ft)	1569.2	1590.6	1610.3	1631.5	1653.2	1675.0	1697.0	127.8	1738.0	1759.0	1779.2	1800.0	1829.0	1842.2	1863.2	125.2
Gas Pres. (In H_2O)	4.4	4.2	4.2	4.2	4.2	4.2	4.2	4.2.3	4.2	4.2	4.0	4.2	4.4	4.8	4.8	4.37
Gas Temp (°F)	66	66	66	66	67	66	66	66.15	65	65	66	66	65	65	65	65.3
Air per Hour (Cu.Ft.)	228	225	227	227	228	227	227	227	225	225	225	225	226	227	225	225.4
Gas per Hour (Cu.Ft.)	267	268	267	265	268	268	268	267.4	268	268	272	267	268	267	267	268
Air Temp. (°F)	69	69	69	69	68	66	67	68.15	67	67	67	66	65	65	65	66
Air Pres. (In. H_2O)	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.4	2.4	2.4	2.4	2.4	2.46
Wt. Cal. H_2O (Lbs.)	179	260	331	400	475	537.5	600	421	179	255	328	405	468	547	624	445
Temp. Cal. H_2O Ent.	60	66	61	62	62	62	63	62.55	63	62	63	63	63	63	63	62.85
Temp. Cal. H_2O Leaving	92	98	99	101	102	112	100	100.3	98	100	100	100	100	101	102	100.15
% Gas Throttle	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
Temp. Jacket H_2O (Ent. Head)	59	60	61	62	62	62	63	61	69	69	69	69	69	69	69	69
Temp. Jacket H_2O (Leave Head)	69	76	72	74	74	69	69.5	72	90.5	82	88	91.5	90	93	95	90
Temp. Jacket H_2O (Ent Back)	59	60	61	62	62	62	63	61	69	69	69	69	69	69	69	69
Temp. Jacket H_2O (Leave Back)	73	76	76	76	71	72	72.5	75.1	90	87	91	91.5	89	89	90	89.65
Wt. Jacket H_2O (Back)	545	754	944	1154	1480	1806	2115	1570	511	636	760	875	993	1124	1265	754
Wt. Jacket H_2O (Front)	185.5	324	448.5	589	182*	441	658	1054	182	234	278	333	380	429	474	292

* Tank emptied.

LOG SHEET FOR BOGART GAS ENGINE TEST

TEST No. 5

Date April 5, 1913
Barometer 29.212 in. Hg. Room Temp. 74°F
Fuel City Gas Density
Clearance Volume 19.04 %
Conditions of Test Variable Jacket Water.

TEST No. 6

Date April 5, 1913
Barometer 29.212 in. Hg Room Temp 74°F
Fuel City Gas, Density
Clearance Volume 19.04 %
Conditions of Test Variable Jacket Water.

ITEM	0	5	10	15	20	25	30	AV.	0	5	10	15	20	25	30	AV.
R.P.M.	270	262	270	266	268	264	262	266	266	266	266	264	264	262	262	264
Wt. on Scale (Lbs.)	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65
Meter (Cu.Ft.)	2237.5	2258.5	2279	2301	2319.8	2341	2363	125.5	2445	2466	2486	2518	2529	2550	2571	126
Gas Pres. (In. H_2O)	4.0	3.8	3.8	4.2	4.0	4.4	4.2	4.05	4.2	4.6	4.2	4.2	4.2	4.0	4.0	4.2
Gas Temp (°F)	64	64	64	64	62	63	64	63.4	65	65	64	67	68	67	67	66.3
Air per Hour (Cu.Ft.)	227	225	226	227	225	225	227	226	225	225	225	225	225	225	225	225
Gas per Hour (Cu.Ft.)	265	265	266	267	265	263	260	264.5	255	255	260	265	263	265	265	261
Air Temp. (°F)	56	55	56	56	61	63	69	58.6	65	65	64	65	66	66	66	65.3
Air Pres. (In. H_2O)	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Wt. Cal. H_2O (Lbs.)	174	255	335	413	489	570	658	484	179	260	340	420	500	585	665	486
Temp. Cal. H_2O Ent.	63	63	62	61	60	60	60	61.3	60	59	59	60	60	61	61	60
Temp. Cal. H_2O Leaving	98	98	98	97	96	95	94	96.6	95	94	94	94	94	94	95	94.3
% Gas Throttle	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
Temp. Jacket H_2O (Ent. Head)	64	64	62	61	61	60	60	61.7	60	59	60	61	62	62	62	61
Temp. Jacket H_2O (Leave Head)	147	148	122	160	140	156	162	148	176	161	168	190	168	176	169	172.6
Temp. Jacket H_2O (Ent Back)	64	64	62	61	61	60	60	61.7	60	59	60	61	62	62	62	61
Temp. Jacket H_2O (Leave Back)	160	167	148.5	139	148	155	161	154	166	171	175	178	180	181	182	176.1
Wt. Jacket H_2O (Back)	518	540	590	634	664	691	722	204	190	202	215	229	239	247	257	67
Wt. Jacket H_2O (Front)	182	196	220	232.5	259	272	282	100	535	560	583	604	627	652	675	140

LOG SHEET FOR BO'GART GAS ENGINE TEST

TEST No 7

Date April 7, 1913
Barometer 29.212 in. Hg. Room Temp. 74°
Fuel City Gas Density
Clearance Volume 19.04 %
Conditions of Test Variable Mixture.

TEST No 8

Date April 7, 1913
Barometer 29.212 in. Hg. Room Temp 74°
Fuel City Gas Density
Clearance Volume 19.04 %
Conditions of Test Variable Mixture

ITEM	0	5	10	15	20	25	30	AV.	0	5	10	15	20	25	30	AV.
R.P.M.	264	260	254	256	258	260	258	258.6	258	258	270	264	268	266	264	264
Wt. on Scale (Lbs.)	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65
Meter (Cu.Ft.)	2882	2905	2929	2953	2976	3009	3033	151	3100	3124	3145	3167	3189	3211	3233	133
Gas Pres. (In. H_2O)	4.8	4.6	4.8	4.6	4.8	4.6	4.8	4.71	4.8	4.6	4.6	4.4	4.6	4.6	4.4	4.57
Gas Temp (°F)	70	70	70	70	71	71	71	70.4	71	71	71	71	71	71	71	71
Air per Hour (Cu.Ft.)	220	220	220	220	220	220	220	220	225	225	225	225	225	225	225	225
Gas per Hour (Cu.Ft.)	293	294	291	292	292	293	292	292.5	280	278	279	279	279	280	275	278.5
Air Temp. (°F)	63	63	64	64	63	64	64	63.5	63	63	63	64	64	64	64	63.5
Air Pres. (In. H_2O)	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	24	2.4	2.4	2.4	2.4
Wt. Col. H_2O (Lbs.)	179	260	340	423	505	580	657	478	179	258	331	408	485	560	643	464
Temp. Col. H_2O Ent.	58	58	58	58	57	57	57	57.5	58	58	58	58	58	59	60	7.84
Temp. Col H_2O Leaving	91	91	91	92	93	93	89	91.5	94	89	89	89	89	90	90	90
% Gas Throttle	100	100	100	100	100	100	100	100	77	77	77	77	77	77	77	77
Temp. Jacket H_2O (Ent. Head)	58	58	58	58	57	57	57	57.5	58	58	58	58	58	59	59	58.3
Temp. Jacket H_2O (Leave Head)	112	114	76	104	110	105	103	103.4	113	114	111	116	115	117	119	115
Temp. Jacket H_2O (Ent. Back)	58	58	58	58	57	57	57	57.5	58	58	58	58	58	59	59	58.3
Temp. Jacket H_2O (Leave Back)	111	109	108	109	110	110	111	112	115	112	115	112	113	114	116	114
Wt. Jacket H_2O (Back)	484	548	610	667	729	785	843	359	499	568	621	682	747	797	854	355
Wt. Jacket H_2O (Front)	167	185	243	276	299	320	346	179	172	193	211	230	253	271	293	121

LOG SHEET FOR BO'GART GAS ENGINE TEST

TEST Nº 9

Date April, 7, 1913
Barometer 29.212 in. Hg. Room Temp. 74°
Fuel City Gas Density
Clearance Volume 19.04 %
Conditions of Test Variable Mixture

TEST Nº 10

Date April 7, 1913
Barometer 29.212 in. Hg. Room Temp 74°
Fuel City Gas Density
Clearance Volume 19.04 %
Conditions of Test Variable Mixture.

ITEM	0	5	10	15	20	25	30	AV.	0	5	10	15	20	25	30	AV.
R.P.M.	258	260	256	256	260	266	258	259	274	276	274	270	276	274	274	274
Wt. on Scale (Lbs.)	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65
Meter (Cu.Ft.)	3354	3375	3395	3415	3434	3454	3474	120	3542	3561	3581	3599	3619	3639	3658	116
Gas Pres. (In. H_2O)	4.6	4.6	4.8	4.6	4.8	4.2	4.4	4.57	5.2	5.0	5.0	5.0	5.0	4.8	5.0	5.0
Gas Temp (°F)	72	72	72	72	72	72	72	72	74	75	75	76	76	77	77	75.7
Air per Hour (Cu.Ft.)	225	225	225	225	225	230	230	226	228	230	227	225	230	230	228	229.3
Gas per Hour (Cu.Ft.)	258	254	251	250	253	255	252	253.3	237	241	238	236	250	234	240	239.4
Air Temp. (°F)	64	64	64	66	63	64	61	64	72	75	73	73	74	73	74	73.4
Air Pres. (In. H_2O)	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Wt. Cal. H_2O (Lbs.)	181	253	320	390	455	521	584	403	180	263	352	435	524	615	710	530
Temp. Cal. H_2O Ent.	59	59	59	59	59	59	59	59	59	59	59	59	59	60	61	59.4
Temp. Cal H_2O Leaving	92	98	98	99	99	101	101	98.3	93	90	96	90	91	90	92	91
% Gas Throttle	67	67	67	67	67	67	67	67	64	64	64	64	64	64	64	64
Temp. Jacket H_2O (Ent. Head)	59	59	59	59	59	59	59	59	59	59	59	59	59	59	59	59
Temp. Jacket H_2O (Leave Head)	106	107	109	105	107	108	110	107.5	110	114	117	120	112	132	114	117
Temp. Jacket H_2O (Ent. Back)	59	59	59	59	59	59	59	59	59	59	59	59	59	59	59	59
Temp. Jacket H_2O (Leave Back)	106	105	106	107	108	109	109	107	116	109	112	112	112	112	112	112.4
Wt. Jacket H_2O (Back)	518	596	670	746	813	883	955	437	495	568	638	713	771	840	904	409
Wt. Jacket H_2O (Front)	178	203	229	255	278	303	327	149	170	195	214	234	257	276	297	127

LOG SHEET FOR BO'GART GAS ENGINE TEST

TEST No 11

Date April 12, 1913
Barometer 29.421 in. Hg. Room Temp. 68°F
Fuel City Gas Density
Clearance Volume 19.04 %
Conditions of Test Variable Ignition

TEST No 12

Date April 12, 1913
Barometer 29.421 in. Hg. Room Temp. 68°F
Fuel City Gas Density
Clearance Volume 19.04 %
Conditions of Test Variable Ignition

ITEM	0	5	10	15	20	25	30	AV.	0	5	10	15	20	25	30	AV.
R. P. M.	256	262	254	262	262	256	254	258	254	254	250	250	240	250	242	248.6
Wt. on Scale (Lbs.)	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65
Meter (Cu. Ft.)	3801	3822	3844	3866	3888	3910	39325	131.5	3988	4008	4028	4051	4071	4092	4113	125
Gas Pres. (In. H_2O)	3.0	3.0	2.8	2.8	2.8	2.8	2.8	2.85	4.0	4.0	4.0	4.0	3.8	3.8	3.8	3.9
Gas Temp (°F)	65	66	66	65	65	65	66	65.4	66	66	66	66	66	66	66	66
Air per Hour (Cu. Ft.)	223	220	220	223	223	223	225	222.4	223	222	221	220	218	217	220	220
Gas per Hour (Cu. Ft.)	273	277	277	283	280	278	278	278	272	268	273	270	277	267	271	271
Air Temp. (°F)	58	57	57	58	58	59	59	58	58	59	59	58	58	58	58	58.2
Air Pres. (In. H_2O)	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Wt. Cal. H_2O (Lbs.)	172	250	327	404	476	550	623	451	179	254	328	404	474	550	618	439
Temp. Cal. H_2O Ent.	68	68	68	68	68	68	68	68	62	60	59	60	63	65	67	62.4
Temp. Cal. H_2O Leaving	101	102	103	103	104	105	105	103	104	88	91	91	94	97	97	94
% Gas Throttle	93	93	93	93	91	87	85	91	90	90	90	90	90	90	90	90
Temp. Jacket H_2O (Ent. Head)	68	68	68	68	68	68	68	68	62	60	59	59	62	64	66	62
Temp. Jacket H_2O (Leave Head)	120	120	123	126	128.5	134.5	131	126	130	134	135	136	136	137	140	135.6
Temp. Jacket H_2O (Ent. Back)	68	68	68	68	68	68	68	68	62	60	59	59	62	64	66	62
Temp. Jacket H_2O (Leave Back)	121.5	122	123	124.5	126	129	132	125.4	130	134	135	136	136	137	140	135.6
Wt. Jacket H_2O (Back)	484	544	599	655	712	763	818	334	496	545	585	628	670	712	755	259
Wt. Jacket H_2O (Front)	178	200	223	242	263	281	301	123	169	185	200	217	238	256	272	103

LOG SHEET FOR BO'GART GAS ENGINE TEST

TEST Nº 13

Date April 12, 1913
Barometer 29.421 in. Hg. Room Temp. 68°F
Fuel City Gas Density
Clearance Volume 19.04%
Conditions of Test Variable Ignition

TEST Nº 14

Date April 12, 1913
Barometer 29.421 in. Hg. Room Temp. 68°F
Fuel City Gas Density
Clearance Volume 19.04%
Conditions of Test Variable Ignition.

ITEM	0	5	10	15	20	25	30	AV.	0	5	10	15	20	25	30	AV.
R.P.M.	252	252	254	256	260	256	262	256	256	254	250	250	254	256	252	253.2
Wt. on Scale (Lbs.)	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65
Meter (Cu.Ft.)	4146	4168	4190	4211	4232	4254	4275	129	4428	4450	4472	4493	4515	4536	4550	122
Gas Pres. (In. H_2O)	3.6	3.6	3.4	3.0	2.8	2.6	2.2	3.03	3.8	3.8	3.8	3.8	3.8	3.8	3.6	3.77
Gas Temp (°F)	66	66	66	66	66	66	66	66	73	74	74	74	75	75	75	74.3
Air per Hour (Cu.Ft.)	220	220	220	220	220	220	220	220	225	225	224	225	225	225	225	225
Gas per Hour (Cu.Ft.)	265	268	268	275	275	275	275	271.6	278	275	270	274	276	275	277	275
Air Temp. (°F)	59	59	58	58	58	59	59	585	63	63	62.5	62	63	64	63	63
Air Pres. (In. H_2O)	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Wt. Col. H_2O (Lbs.)	182	251	320	385	450	518	586	402	176	253	330	400	469	540	610	434
Temp. Col. H_2O Ent.	67	68	68	68	68	68	68	68	60	59	59	59	59	59	61	59.4
Temp. Col H_2O Leaving	104	104	105	105	106	106	106	105.5	94	97	98	99	99	99	99	98
% Gas Throttle	93	93	100	100	100	100	100	98	88	88	88	88	88	88	88	88
Temp. Jacket H_2O (Ent. Head)	67	67	67	67	68	68	68	67.4	59	59	59	59	59	59	61	59.3
Temp. Jacket H_2O (Leave Head)	128	132	129	127	128	129	130	129	113	121	127	131	135	105	119	121.6
Temp. Jacket H_2O (Ent. Back)	67	67	67	67	68	68	68	67.4	59	59	59	59	59	59	61	59.3
Temp. Jacket H_2O (Leave Back)	140	123	129	134	137	139	133	133.4	120	126	134	135	126	122	121	126.6
Wt. Jacket H_2O (Back)	508	577	624	670	712	788	803	295	490	537	575	611	667	721	776	286
Wt. Jacket H_2O (Front)	181	201	220	239	266	282	301	120	179	201	218	235	250	274	296	117

LOG SHEET FOR BO'GART GAS ENGINE TEST

TEST Nº 15

Date April 12, 1913
Barometer 29.421 in. Hg. Room Temp 68°F
Fuel City Gas Density
Clearance Volume 19.04 %
Conditions of Test Variable Ignition

TEST Nº 16

Date April 12, 1913
Barometer 29.421 in. Hg. Room Temp 68°F
Fuel City Gas Density
Clearance Volume 19.04 %
Conditions of Test Variable Ignition

ITEM	0	5	10	15	20	25	30	AV.	0	5	10	15	20	25	30	AV.
R.P.M.	246	240	244	240	242	250	250	244.6	230	238	248	244	242	240	243	240.7
Wt. on Scale (Lbs.)	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65
Meter (Cu.Ft.)	4602	4625	4646	4667	4689	4689	4731	129	4803	4825	4847	4869	4890	4914	4934	131
Gas Pres. (In. H_2O)	4.4	4.6	4.0	4.4	4.2	4.2	4.6	4.34	4.8	4.8	4.8	5.0	5.0	5.0	5.0	4.92
Gas Temp (°F)	74	73	72	72	72	72	72	72.4	71	71	70	70	71	70	70	70.4
Air per Hour (Cu.Ft.)	220	220	220	220	223	224	225	221.5	225	225	225	226	225	226	225	225.3
Gas per Hour (Cu.Ft.)	273	272	273	270	271	265	270	270.6	278	275	275	273	274	267	275	274.2
Air Temp. (°F)	62	62	62	60	62	62	62	61.7	62	61	61	62	61	61	61	61.3
Air Pres. (In. H_2O)	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Wt. Col. H_2O (Lbs.)	181	253	328	400	474	547	614	433	179	270	353	439	520	604	685	506
Temp. Col. H_2O Ent.	64	65	66	66	66	67	67	66	67	67	67	67	67	67	67	67
Temp. Col. H_2O Leaving	101	103	103	104	105	106	106	104	98	100	102	102	103	103	103	101.6
% Gas Throttle	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88
Temp. Jacket H_2O (Ent. Head)	64	64	65	66	66	66	66	65.3	66	66	67	67	67	67	66	66.5
Temp. Jacket H_2O (Leave Head)	125	119	120	128	132	112	116	120	126	126	127	128	129	130	131	128.2
Temp. Jacket H_2O (Ent. Back)	64	64	65	66	66	66	66	65.3	66	66	67	67	67	67	66	66.5
Temp. Jacket H_2O (Leave Back)	122	122	124	124	127	130	133	126	114	110	110	110	114	116	117	113
Wt. Jacket H_2O (Front)	183	206	228	250	277	292	314	131	181	200	217	236	256	273	290	109
Wt. Jacket H_2O (Back)	511	565	620	673	723	775	819	308	529	613	692	775	845	914	983	454

LOG SHEET FOR BOGART GAS ENGINE TEST

TEST Nº 17

Date April 19, 1913
Barometer 29.592 in Hg Room Temp. 76°F
Fuel Gasoline Density .736
Clearance Volume 19.04 %
Conditions of Test Variable Mixture

TEST Nº 18

Date April 19, 1913
Barometer 29.592 in. Hg. Room Temp 76°F
Fuel Gasoline Density .736
Clearance Volume 19.04 %
Conditions of Test Variable Mixture

ITEM	0	5	10	15	20	25	30	AV.	0	5	10	15	20	25	30	AV.
R.P.M.	292	290	292	292	296	300	292	293.4	304	304	304	304	304	304	308	304.6
Wt. on Scale (Lbs)	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
Meter (Cu.Ft)																
Gas Pres. (In. H_2O)																
Gas Temp (°F)																
Air per Hour (Cu.Ft)	278	277	277	278	278	277	277	277.4	278	279	278	278	277	277	275	277.6
Gas per Hour (Lbs.t.)	1.72	2.6	3.5	4.4	5.2	6.1	7.0	5.3	1.3	2.1	2.9	3.7	4.5	5.2	6.0	47
Air Temp. (°F)	61	63	62	62	63	62	64	62.4	63	64	64	65	66	64	65	64.4
Air Pres. (In. H_2O)	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Wt. Cal. H_2O (Lbs.)	166	233	300	365	430	495	560	394	167	252	345	425	507	595	680	513
Temp. Cal. H_2O Ent.	65	65	64	64	62	61	60	63	59	58	58	58	58	58	59	58.3
Temp. Cal H_2O Leaving	114	114	113	113	112	110	109	112.2	108	98	99	99	99	99	98	99.8
% Gas Throttle																
Temp. Jacket H_2O (Ent. Head)	65	65	64	65	64	61	60	63.4	59	58	58	58	58	58	59	58.3
Temp. Jacket H_2O (Leave Head)	110	112	118	115	115	115	112	114	117	116	116	117	118	116	115	116.4
Temp. Jacket H_2O (Ent. Back)	65	65	64	65	64	61	60	63.4	59	58	58	58	58	58	59	58.3
Temp. Jacket H_2O (Leave Back)	118	118	119	118	118	118	118	118.3	119	120	121	121	122	123	123	121.3
Wt. Jacket H_2O (Back)	566	621	677	726	779	834	888	322	502	553	603	652	700	749	798	296
Wt. Jacket H_2O (Front)	207	228	248	266	285	305	325	118	182	202	222	242	261	281	300	118

LOG SHEET FOR BOGART GAS ENGINE TEST

TEST Nº 19

Date April 19, 1913
Barometer 29.592 in. Hg. Room Temp. 76°F
Fuel Gasoline Density .736
Clearance Volume 19.04 %
Conditions of Test Variable Mixture.

TEST Nº 20

Date April 21, 1913
Barometer 29.32 in Hg Room Temp 85°F
Fuel City Gas Density
Clearance Volume 25%
Conditions of Test Variable Mixture

ITEM	0	5	10	15	20	25	30	AV.	0	5	10	15	20	25	30	AV.
R.P.M.	308	310	318	312	316	310	315	312.7	269	260	258	258	260	262	266	261.1
Wt. on Scale (Lbs.)	70	70	70	70	70	70	70	70	65	65	65	65	65	65	65	65
Meter (Cu.Ft.)									5208	5223	5248	5272	5295	5321	5394	136
Gas Pres. (In H_2O)									4.0	4.2	4.2	4.2	4.0	4.0	3.8	4.06
Gas Temp (°F)									88	88	88	88	88	88	88	88
Air per Hour (Cu.Ft.)	275	277	276	277	277	276	277	276.6	250	247	245	250	247	247	248	247.7
Gas per Hour (Lbs.)	7.5	8.1	* 1.7	2.3	3.0	3.6	4.3	4.0	308	310	305	297	300	310	313	306
Air Temp. (°F)	65	64	66	66	69	66	67	66.2	83	83	84	84	83	84	84	83.6
Air Pres. (In. H_2O)	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.0	2.8	2.8	2.8	3.0	3.0	3.0	2.91
Wt. Col. H_2O (Lbs.)	166	246	332	412	495	575	656	490	159	235	315	398	478	559	630	471
Temp. Col. H_2O Ent.	62	63	63	63	63	63	64	63	61	60	60	59	59	59	59	59.6
Temp. Col. H_2O Leaving	105	106	108	108	109	109	109	107.7	103	101	99	99	97	98	99	99.3
% Gas Throttle									87	87	87	87	87	87	87	87
Temp. Jacket H_2O (Ent. Head)	62	63	63	64	64	64	64	63.7	62	61	60	60	60	60	60	60.4
Temp. Jacket H_2O (Leave Head)	113	119	117	117	119	124	125	119	140	130	128	128	131	143	141	134
Temp. Jacket H_2O (Ent. Back)	62	63	63	64	64	64	64	63.7	60	61	60	60	60	60	60	60.4
Temp. Jacket H_2O (Leave Back)	126	113	112	116	117	120	120	117.8	129	129	129	129	128	128	129	128.6
Wt. Jacket H_2O (Back)	486	565	645	712	785	850	915	429	525	576	627	677	728	778	822	297
Wt. Jacket H_2O (Front)	181	203	227	249	271	293	314	133	188	206	222	239	256	271	283	95

* Tank filled

LOG SHEET FOR BOGART GAS ENGINE TEST

TEST No. 21

Date April 21, 1913
Barometer 29.32 in. Hg. Room Temp 85°F
Fuel City Gar Density
Clearance Volume 25%
Conditions of Test Variable Mixture

TEST No. 22

Date April 23, 1913
Barometer 29.432 in. Hg Room Temp 75°F
Fuel Gasoline Density .732
Clearance Volume 25.%
Conditions of Test Variable Mixture

ITEM	0	5	10	15	20	25	30	AV.	0	5	10	15	20	25	30	AV.
R. P. M.	264	260	258	258	260	262	266	261.1	340	340	336	334	320	328	328	332.6
Wt. on Scale (Lbs.)	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65
Meter (Cu. Ft.)	5437	5459	5482	5504	5527	5551	5573	136								
Gas Pres (In H_2O)	4.0	4.2	4.2	4.4	4.4	4.0	4.2	4.2								
Gas Temp (°F)	88	88	88	88	88	88	88	88								
Air per Hour (Cu. Ft.)	250	253	252	250	250	254	250	251.3	292	292	292	292	292	292	292	292
Gas per Hour (Cu. Ft.) / (Lbs.)	280	285	291	285	280	290	287	285.4	3.3	4.05	4.85	5.7	6.6	7.6	8.5	5.2
Air Temp (°F)	84	84	84	84	83	83	84	83.7	76	75	75	76	76	76	77	76
Air Pres. (In. H_2O)	3.0	3.0	2.8	3.0	2.8	2.8	2.8	2.88	3.8	3.8	3.6	3.8	3.8	3.8	3.8	3.8
Wt. Col. H_2O (Lbs.)	79	134	228	310	395	480	548	469	180	254	328	403	475	543	617	437
Temp Col. H_2O Ent.	61	61	62	62	62	62	62	61.8	67	66	66	66	67	66	67	66.4
Temp Col H_2O Leaving	104	104	105	99	100	105	109	107.3	117	117	117	115	115	115	117	116.2
% Gas Throttle	67	67	67	67	67	67	67	67								
Temp. Jacket H_2O (Ent. Head)	61	61	62	62	62	62	62	61.8	66	65	66	66	66	67	66	66
Temp. Jacket H_2O (Leave Head)	130	123	126	121	118	156	145	132.7	129	130	135	140	105	133	143	131.4
Temp. Jacket H_2O (Ent. Back)	61	61	62	62	62	62	62	61.8	66	65	66	66	66	67	66	66
Temp. Jacket H_2O (Leave Back)	135	136	132	132	129	131	137	133.1	129	134	137	125	120	126	129	128.6
Wt. Jacket H_2O (Back)	545	593	645	698	755	813	852	307	525	577	627	693	762	815	861	336
Wt. Jacket H_2O (Front)	182	200	222	243	266	282	292	110	185	207	223	240	268	285	298	113

LOG SHEET FOR BO'GART GAS ENGINE TEST

TEST No 23

Date April 23, 1913
Barometer 29.432" Hg. Room Temp. 75°F
Fuel Gasoline Density .732
Clearance Volume 25 o/o
Conditions of Test Variable Mixture

TEST No 24

Date April 23, 1913
Barometer 29.432" Hg Room Temp 75°F
Fuel Gasoline Density .732
Clearance Volume 25 o/o
Conditions of Test Variable Mixture

ITEM	0	5	10	15	20	25	30	AV.	0	5	10	15	20	25	30	AV.
R.P.M.	336	340	340	348	344	342	340	342	298	298	298	288	300	300	300	297.4
Wt. on Scale (Lbs.)	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65
Meter (Cu.Ft.)																
Gas Pres. (In H_2O)																
Gas Temp (°F)																
Air per Hour (Cu.Ft.)	294	295	293	294	293	293	290	293	288	290	290	290	290	290	290	289.8
Gas per Hour (Lbs. / Cu.Ft.)	1.35	2.1	2.9	3.7	4.4	5.2	6.0	4.65	1.2	1.8	2.3	3.0	3.5	4.05	4.65	3.45
Air Temp. (°F)	76	76	76	76	76	77	77	76.3	76	77	76	77	77	76	78	76.7
Air Pres. (In. H_2O)	3.8	3.8	3.8	3.8	3.8	3.8	3.6	3.77	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Wt. Col. H_2O (Lbs.)	180	240	297	375	467	562	653	473	179	260	340	431	495	570	647	468
Temp. Col. H_2O Ent.	68	68	68	68	68	68	68	68	69	69	69	70	69	69	69	69
Temp. Col H_2O Leaving	127	128	130	109	109	109	110	117.4	114	114	114	116	117	118	117	115.7
% Gas Throttle																
Temp. Jacket H_2O (Ent. Head)	68	67	67	67	68	67	68	67.4	69	68	68	69	68	69	69	68.6
Temp. Jacket H_2O (Leave Head)	130	113	153	141	130	130	133	133	119	119	122	132	141	120	146	126.5
Temp. Jacket H_2O (Ent. Back)	68	67	67	67	68	67	68	67.4	69	68	68	69	68	69	69	68.6
Temp. Jacket H_2O (Leave Back)	119	123	128	132	132	133	134	128.7	136	136	136	137	141	143	144	139
Wt. Jacket H_2O (Back)	495	571	628	689	748	806	865	370	501	557	606	662	706	753	801	300
Wt. Jacket H_2O (Front)	182	210	225	240	260	280	300	118	182	206	228	251	269	285	298	116

LOG SHEET FOR BO'GART GAS ENGINE TEST

TEST Nº 25.

Date April 30, 1913
Barometer - 29.51 in. Hg Room Temp. - 81°
Fuel - City Gas Density
Clearance Volume - 27.76 %
Conditions of Test - Variable Mixture

TEST Nº 26.

Date April 30, 1913
Barometer - 29.51 in. Hg Room Temp. - 81°
Fuel - City Gas Density
Clearance Volume - 27.76%
Conditions of Test - Variable Mixture

ITEM	0	5	10	15	20	25	30	AV.	0	5	10	15	20	25	30	AV.
R. P. M.	246.	252.	254.	260.	252.	254.	252.	254.3	232.	236.	236.	234.	236.	232.	228.	223.4
Wt. on Scale (Lbs.)	65	65	65.	65.	65	65	65.	65.	65.	65.	65.	65.	65.	65.	65.	65.
Meter (Cu.Ft.)	6365.	6388.	6411.	6434.	6457.	6481.	6505.	140.	6557.	6578.	6599.	6620.	6642.	6663.	6685.	128.
Gas Pres. (In. H_2O)	4.4	4.4	4.2	4.6	4.4	4.4	4.4	4.4	4.6	4.6	4.8	4.8	4.8	4.8	4.8	4.74
Gas Temp (°F)	85.	85.	85.	85.	85.	85.	86.	85.1	86.	86.	86.	86.	86.	86.	86.	86.
Air per Hour (Cu.Ft.)	225.	225.	225.	223.	230.	230.	230.	227.	225.	225.	225.	225.	230.	228.	230.	227.
Gas per Hour (Cu.Ft.)	310.	300.	300.	300.	305.	305.	305.	303.6	277.	280.	278.	275.	280.	280.	278.	2787
Air Temp. (°F)	81.	81.	81.	81.	81.	81.	81.	81.	82.	81.	82.	81.	81.	81.	82.	81.3
Air Pres. (In. H_2O)	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Wt. Cal. H_2O (Lbs.)	170.	265.	346.	415.	484.	546.	615.	445.	178.	240.	290.	350.	410.	470.	530.	352.
Temp. Cal. H_2O Ent.	67.	66.	66.	66.	66.	66.	66.	66.	66.	66.	64.	64.	66.	65.	66.	65.3
Temp. Cal H_2O Leaving	94.	95.	107.	107.	110.	111.	111.	107.	107.	121.	109.	108.	108.	107.	107.	109.6
% Gas Throttle	100.	100.	100.	100.	100.	100.	100.	100.	62.	62.	62.	62.	60.	60.	60.	61.1
Temp. Jacket H_2O (Ent. Head)	67.	66.	67.	67.	67.	68.	68.	67.1	68.	69.	64.	66.	66.	66	66	66.4
Temp. Jacket H_2O (Leave Head)	118.	120.	122.	124.	128.	130.	132.	125.	127.	149.	104.	133.	141.	139.	109.	130.
Temp. Jacket H_2O (Ent. Back)	67.	66.	67.	67.	67.	68.	68.	67.1	68.	69.	64.	66.	66.	66.	66.	66.4
Temp. Jacket H_2O (Leave Back)	130.	135	133.	133.	134.	136.	136.	134.	128.	130.	140.	123.	118	124.	127.	127.
Wt. Jacket H_2O (Back)	530.	577.	629.	681.	733.	783.	833.	303.	495.	541.	579.	639.	704.	755.	802.	307.
Wt. Jacket H_2O (Front)	132.	154.	177.	198.	218.	238.	256.	124.	182.	192.	227.	245.	256.	277.	300.	118.

[illegible]	TEST [illegible] 27	TEST [illegible]
	[illegible] May 2, 1913	[illegible]
	[illegible] 29.353" Hg. [illegible] 83°F.	[illegible]
	[illegible] Gasoline [illegible] .731	[illegible]
	[illegible] 27.76%	[illegible]
	[illegible] Variable Mixture	[illegible]

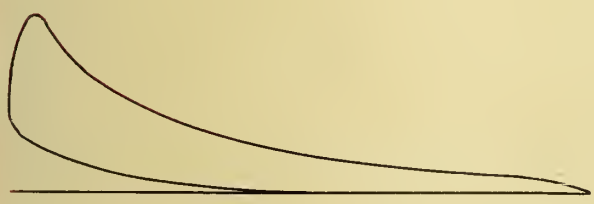
ITEM	0	5	10	15	20	25	30	35	0	5	10	15	20	25	30	35
[illegible]	264	298	302	296	294	294	294	292.3								
Wt. on Scale [illegible]	65	65	65	65	65	65	65	65								
Meter [illegible]																
[illegible]																
Gas Temp. [illegible]																
[illegible]	280	273	270	272	272	272	274	273.3								
[illegible] (Lbs.)	1.35	2.1	2.9	3.5	4.3	5.05	5.8	4.45								
Air Temp. [illegible]	88	87.5	87.5	87.3	88.	88.5	88	87.8								
Air Press. [illegible]	3.9	3.7	3.7	3.5	3.5	3.5	35	3.61								
Wt. [illegible]	145						613.5	468.5								
Temp. [illegible]	64	64	65	65	66	67	68	65.4								
Temp. [illegible]	100	102	102	104	100	128	125	108.7								
% Gas Throttle																
Temp. [illegible]	64	64	65	65	66	67	68	65.4								
Temp. Jacket H_2O [illegible]	140	143	128	133	131	135	140	137.3								
Temp. [illegible] H_2O	64	64	65	65	66	67	68	65.4								
Temp. Jacket H_2O [illegible]	126	126	131	119	125	131	132	127.1								
Wt. Jacket H_2O [illegible]	514						893	329								
Wt. Jacket H_2O (Front)	114						205	91								

INDICATOR CARDS

VARIABLE JACKET WATER TEMPERATURES
COMPRESSION VOLUME 19% PISTON DISPLACEMENT.

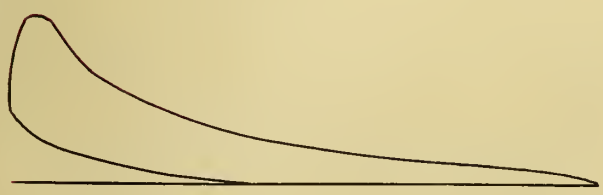
TEST No 1. M.E.P. 51.4 #/□"
Temp. Jacket Water 73 °F.

TEST No 4 M.E.P. 51.5 #/□"
Temp. Jacket Water 130°F.



TEST No 2 M.E.P. 50.15 #/□"
Temp. Jacket Water 90 °F

TEST No 5 M.E.P 52.5 #/□"
Temp. Jacket Water 151 °F

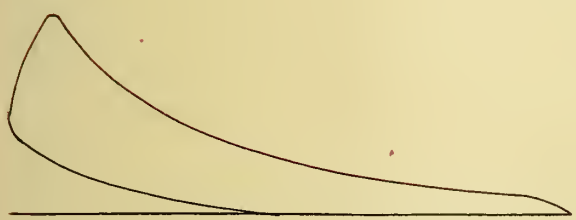


TEST No 3 M.E.P 52.1 #/□"
Temp. Jacket Water 111 °F

TEST No 6 M.E.P. 51.0 #/□"
Temp. Jacket Water 175 °F.

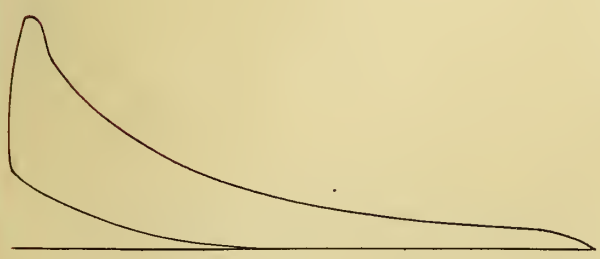
INDICATOR CARDS

VARIABLE MIXTURES
CLEARANCE VOLUME 19% PISTON DISPLACEMENT.



TEST No. 7 M.E.P. 49.11 #/□"
AIR TO GAS RATIO 6.02 TO 1.00

TEST No. 9 M.E.P. 49.73 #/□"
AIR TO GAS RATIO 7.10 TO 1.00

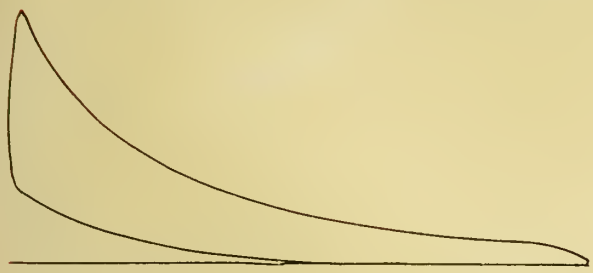


TEST No. 8 M.E.P. 49.70 #/□"
AIR TO GAS RATIO 6.63 TO 1.00

TEST No. 10 M.E.P. 49.72 #/□"
AIR TO GAS RATIO 7.66 TO 1.00

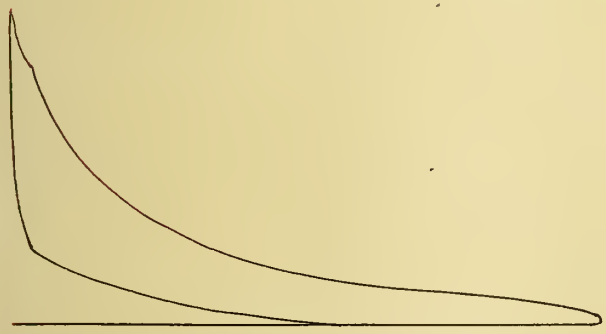
INDICATOR CARDS

VARIABLE IGNITION
CLEARANCE VOLUME 19.09% PISTON DISPLACEMENT



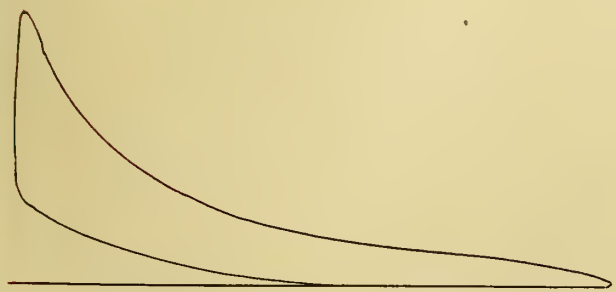
TEST Nº 11 M.E.P. 50.16 #/□"
ANGLE OF CRANK 31.9°

TEST Nº 14 M.E.P. 52.36 #/□"
ANGLE OF CRANK 29.4°



TEST Nº 12 M.E.P. 49.94 #/□"
ANGLE OF CRANK 40.23°

TEST Nº 15 M.E.P. 53.47 #/□"
ANGLE OF CRANK 25.2°



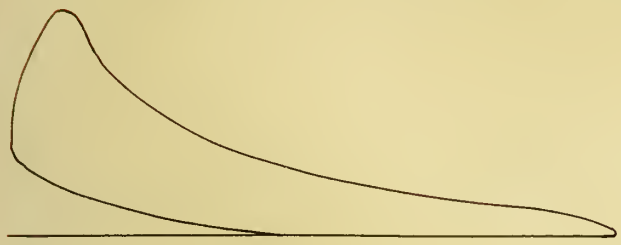
TEST Nº 13 M.E.P. 50.80 #/□"
ANGLE OF CRANK 36.5°

TEST Nº 16 M.E.P. 55.14 #/□"
ANGLE OF CRANK 21.0°

INDICATOR CARDS

VARIABLE GASOLINE AND AIR MIXTURES

CLEARANCE VOLUME 19.04% PISTON DISPLACEMENT



TEST No. 17 M.E.P. - 61.6 #/□"

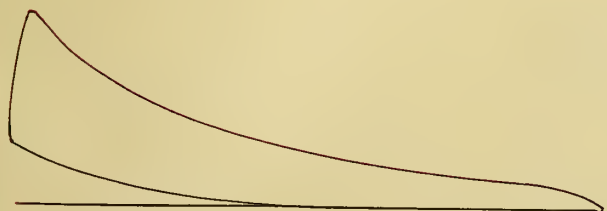
AIR-GASOLINE RATIO - 15.87

TEST No. 18 M.E.P. - 56.6 #/□"

AIR-GASOLINE RATIO - 17.9

TEST No. 19 M.E.P. 57.0 #/□"

AIR-GASOLINE RATIO - 21.00



TEST No. 25 M.E.P. 48.9 #/□"

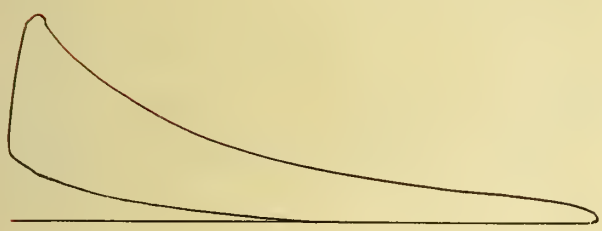
AIR-GAS RATIO - 6.00

TEST No. 26 M.E.P. 49.1 #/□"

AIR-GAS RATO - 6.51

INDICATOR CARDS

VARIABLE AIR TO GAS RATIO
CLEARANCE VOLUME 25% PISTON DISPLACEMENT



TEST Nº 20 M.E.P. 53.3 #/□"
AIR TO GAS RATIO 6.99 TO 1.00

TEST Nº 21 M.E.P. 52.2 #/□"
AIR TO GAS RATIO 7.04 TO 1.00

INDICATOR CARDS

VARIABLE GASOLINE AND AIR MIXTURE

COMPRESSION VOLUME 25% PISTON DISPLACEMENT

TEST No. 22 M.E.P. - 53.2 #/□"
AIR-GASOLINE RATIO- 18.8

TEST No. 23 M.E.P. - 52.6 #/□"
AIR-GASOLINE RATIO- 21.7

TEST No. 24 M.E.P. - 56.1 #/□"
AIR-GASOLINE RATIO- 27.6

COMPRESSION VOLUME 27.76% PISTON DISPLACEMENT

TEST No. 27 M.E.P. - 50.8 #/□"
AIR-GASOLINE RATIO - 16.07

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